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THE EDISON ELECTRIC LIGHT.

Proceeding of the Meeting of the Institute, Jan. 21st.

[Continued from page 144.]

Mr. A. E. Outerbridge, Jr., made the following remarks:

MR. CHAIRMAN AND GENTLEMEN—In acceding to the request of the Secretary of the Institute that I should give the members an account of my recent visit to Menlo Park, and the system of electric lighting now being practically tested there, I wish to premise that I do not feel especially well qualified by reason of any superior technical knowledge or experience to do full justice to this most interesting topic, in regard to which there exists a great diversity of opinion among the doctors. I shall not, therefore, venture to express any opinion as to the originality of Mr. Edison's devices or the possible future economy or practicability of his light. I shall merely endeavor to describe, as concisely as possible, for the benefit of our members who may not have had an opportunity of seeing this light, the general plan of operations as I observed it at Menlo Park, and to present a resumé of the history of the matter to be discussed this evening.

It is scarcely necessary for me to explain to you that the problem which Mr. Edison has been endeavoring to solve for the past two years has been the production of an electric illumination by the system

known as "incandescence" of a solid material, as distinguished from the electric arc between the carbon pencils, with which we are all so familiar. That this problem is by no means a new one many of you know, and Mr. Edison is not, and does not claim to be, the pioneer in this field of research. As long ago as 1845 an American inventor named Starr obtained a patent in England for a system of incandescent electric lighting, the specification reading almost like a description of Mr. Edison's apparatus.*

Starr's schemes were prematurely extinguished on account of his sudden death, but he was followed by a number of others who produced incandescent lamps depending on the same principles, all of them promising in their embryonic stage brilliant prospects of future usefulness, but they have all failed to fulfill the expectations of their sanguine authors, and have remained buried in almost complete obli-

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* In 1845 an American inventor named Starr took out in England, through his agent, King, a patent (No. 10,919, dated November 4) for producing light by electricity, which contained, among other matter, the following description: "The invention has for its basis the use of metallic conductors, or of continuous carbons, heated to whiteness by the passage of the electric current. The best metal for this purpose is platinum, the best carbon is retort carbon. When carbon is employed it is useful on account of its affinity for oxygen at high temperatures to cover it from air and moisture." Here follows a description of the figure, which shows the thin rod or filament of carbon enclosed in a glass vessel. The patent then continues: "A vacuum is previously established in the bell, and the apparatus veritably forms a barometer, with one of the poles of the battery in communication with the column of mercury and the other with the conductor *D*." The conductor *D* is represented as sealed directly into the glass globe or bell, and the reference to the barometer shows clearly that the vacuum produced was what is known as the Torricellian vacuum, which, as far as the absolute exclusion of air goes, is equal to anything otherwise attainable, and fully equivalent for practical purposes to what Mr. Edison produces in his lamps. If, therefore, these lamps are of any practical use, so also would lamps be if made according to the King patent, which is, of course, open to all the world.

King, or rather Starr, was followed by various inventors and patentees, who modified or improved the details of his general plan, as Staite & Petrie, Loclyguyne, Konn, Bouliguine, Fontaine, and more recently Sawyer. None of these have ever reached any permanent success in the practical application of their systems; how far this has been the result of unfavorable circumstances, and how far it has come from radical defects in their systems, cannot as yet be determined; but it is evident that the ground has been thoroughly planted with devices and with patents, from which will spring a fruitful crop of litigation, should any success on the part of one or other of the closely allied methods make it worth while to contest the validity of rival claims.—*Sanitary Review.*

vion.* It is not unnatural, therefore, that scientists who are cognizant of the immense difficulties in the way of a practical solution of a problem which is, in theory, extremely simple, should hesitate to concede a better fortune to this latest child of even so herculean an inventive genius as Mr. Edison.

The earlier workers in this field relied entirely upon the expensive

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*At a meeting of the French Academy, held March 1, 1858, there was received from M. Jobart a communication in which he speaks as follows:

"I hasten to announce to the Academy the important discovery of the dividing of an electric current for lighting purposes. This current, from a single source, traverses as many wires as may be desired, and gives a series of light ranging from a night lamp to a lighthouse lamp.

"The luminous arc between the carbons produces, as is well known, a very intense, flickering and costly light. M. de Changy, who is a chemist, mechanician and physicist, is thoroughly conversant with the latest discoveries, and has just solved the problem of dividing the electric light.

"In his laboratory, where he has worked alone for the past six years, I saw a battery of twelve Bunsen elements producing a constant luminous arc between two carbons, in a regulator of his own invention—this regulator being the most simple and perfect I have ever seen. A dozen small miner's lamps were also in the circuit, and he could, at pleasure, light or extinguish either one or the other, or all together, without diminishing or increasing the intensity of the light through the extinction of the neighboring lamps. The lamps, which are enclosed in hermetically sealed glass tubes, are intended for the lighting of mines in which there is fire-damp, and for the street lamps, which would by this system be all lighted or put out at the same time on the circuits being opened or closed. The light is as white and pure as Gillard's gas, with which it has one point in common, namely, its production by the incandescence of platinum. The gas pipes are replaced by simple wires, and no explosions, bad smells or fires can take place.

"The trials that have hitherto been made with the object of producing an electric light by means of heated platinum have failed on account of the melting of the wires. This difficulty has been overcome by M. de Changy's dividing regulator. The cost of the light is estimated to be half that of gas. A lamp placed at the masthead of a ship would form a permanent signal for about six months without the necessity of changing the platinum. With several such lights, placed in tubes of colored glass, it would be easy to telegraph by night, as they could be extinguished and relighted rapidly from the deck.

"For lighthouse purposes considerable amplitude can be given to the light. I also saw a lamp so arranged in a thick glass globe that it could be immersed to considerable depths without being extinguished by any movement. This lamp has already been used in the taking of fish, which were attracted towards the light.

"The above slight description will suffice to show to what a variety of applications this discovery can be put. The communication which I have had the honor of laying before the Academy is founded upon no illusion; a lamp was, to my astonishment, lit in the hollow of my hand, and remained alight after I had put it in my pocket with my handkerchief over it."

consumption of zinc in the galvanic battery for their source of electricity, and it is difficult to conceive under such circumstances that an incandescent light, even though perfect in all other respects, could have been made an economic success as compared with gas or other illuminants.

The electrical force is now obtained very much more cheaply by consuming coal in a steam engine, the mechanical force of the engine being converted into electrical force by means of the powerful dynamo-electrical machines. Here, too, great activity has been displayed of late years among inventors in the improvement of these machines, and the modern machines convert mechanical into electrical power as economically, compared to the older forms, as the modern turbine wheel compares with the ancient overshot water wheel in respect to its saving of energy.

The dynamo-machines all depend upon the principle promulgated by Faraday, that when a piece of metal (as a wire) is moved between the poles of a magnet (or cuts the field of magnetic force, as it is technically termed) the electrical equilibrium in the wire is momentarily disturbed, a pulse of electricity flows in one direction while the wire is under the influence of the magnet, and returns in the opposite direction when it is removed from the sphere of attraction.

The earlier forms of magneto-electrical machines—those of Pixii, Saxton, Clarke and others—consisted essentially of a permanent horse-shoe magnet of steel, in front of the poles of which were two bobbins, or spools, of insulated copper wire, wrapped in opposite directions on a soft iron core, and mounted upon a horizontal axis, which was turned by a handle. "When the bobbins were revolved the two spools became alternately magnetized in contrary directions under the influence of the magnet, and in each spool an induced current was produced, the direction of which changed at each half turn."

A simple improvement, called the "commutator," was soon made, by which the two alternating currents were forced to flow into a conducting wire always in the same direction. The earlier machines were only made to produce feeble and intermittent pulses of electricity until the apparatus of Nollet, of Brussells, constructed in 1850, worked a revolution and partially revealed the latent capacities of the principles involved in the apparatus. This machine consisted of forty powerful horse-shoe magnets (capable of sustaining 125 pounds weight each), mounted radially on a cast iron frame. On a horizontal axis,

running through the frame between the poles of the magnets, were four wheels, upon whose peripheries were placed 64 spools of insulated fine copper wire. The wire on all the spools was coiled in the same direction, and the spools could be connected so as to produce at pleasure electricity of high potential or of low tension, just as the different cells of a galvanic battery may be connected to produce similar variations of electrical condition. This machine was run by steam power, and sustained an electric arc which measured, photometrically, equal to 150 Carcel burners.

The next great advance was made in the production of the Siemens armature, in which the wire was wrapped longitudinally on an axis, instead of transversely as in the bobbins.

Then came Wild's machine, which combined the Siemens armature with a new principle, that of the "multiplication of the current." The current induced in the armature is used to charge a large field magnet (electro-magnet), between the poles of which a large Siemens armature was revolved at the rate of 1700 revolutions per minute.

Next came Ladd's modification, in which two Siemens armatures were used, and the permanent magnets were dispensed with altogether. Mr. Ladd found that if the large electro-magnet was once charged with electricity from a battery, or other source, sufficient residual magnetism remained ever afterwards in the soft iron cores to act upon the armature and produce a feeble current in it as soon as it was revolved.

This current was then passed into the coils of wire forming the large field magnet, increasing its strength; this in turn reacted on the armature, and so, in a few moments, a very powerful effect was produced by the building up, as it were, of successive weak impulses.

Other improvements have followed rapidly, such as the soft iron ring armature of Gramme, the modifications of Wallace and Farmer, the Brush machine, and latest in point of time, perhaps, is the machine of Profs. Thomson and Houston, the patent specifications of which were published within a few days past.

Now we come, intelligently I hope, to view the machine in Mr. Edison's laboratory, which is the fountain-head of his electrical power. We are at the first glance impressed by the great size of his field magnets, standing 4½ feet high, weighing, as I was told, upwards of 1100 pounds. The cores are of wrought iron, mounted on heavy blocks of cast iron, and joined together at the top by a wrought iron yoke.

These cores are wrapped with three layers of No. 10 copper wire,

insulated with cotton. The armature [which it seems to me is identical in principle, if not in construction, with Siemens'] revolves in the cylindrical space between the cast iron blocks at about 500 revolutions per minute; there is the usual commutating axle, with copper wire brushes for drawing off the electricity.

The field magnet is "charged" from a separate machine, and the amount of electricity poured into it depends upon the amount of electricity required in the main line. This is ingeniously and beautifully accomplished as follows:

A reflecting galvanometer is placed in the main circuit, and a small fraction of the current is continually passing into it, the amount of deflection of the needle being read by the varying position of a spot of light traveling over a scale, as in the sub-marine telegraph system. A series of resistance coils are placed in the "local circuit" between the charging machine and the field magnet of the generator proper, and a boy who watches the record on the scale cuts out or adds resistance by turning a little wheel, thereby increasing or decreasing the flow of electricity into the field magnets, thus affecting the flow on the main line just sufficiently to bring the spot of light back to its normal position. If the drain on the main conduit is increased by turning on more lights, the galvanometer indicates the fact instantly, the boy in charge pours more electricity into the field magnet, the armature develops more current, and the engine burns more coal by reason of the additional mechanical power required to be converted into additional electrical power.

If we now look at the lamps we will find that they are very simple in construction. There is a small glass bulb, into the neck of which is introduced a smaller bulb, containing two platinum wires, hermetically sealed and terminating inside the lamp in two little metal clips which hold the delicate horse-shoe shaped filament of carbonized paper (when I say delicate I do not mean fragile, for these little conductors are wonderfully tough and elastic, as I proved by twisting and breaking several which Mr. Edison gave me for the purpose of testing their strength). The bulb or globe is attached by the little tube to an exhausting apparatus, which is a combination of an ordinary mercury and a Sprengel pump, and the air is exhausted to the last possible degree of rarity; the end of the tube from which the bulb was blown is now sealed with the blowpipe, leaving merely a little nipple projecting, and the whole thing is hermetically closed. The

platinum wires terminate outside the lamp, in two metal springs, which fit into a socket attached to an ordinary gas bracket; by turning a little thumb-screw the lamp is thrown into the electrical circuit, and the enormous resistance offered by the bad conductivity of the carbon horse shoe, combined with its great infusibility, accounts satisfactorily for the brilliant incandescence which instantly follows. The light is soft and agreeable to the eye, perfectly steady, and of a degree of whiteness that depends upon the specific resistance of each individual carbon horse-shoe; a great difference being noticed in this respect between lamps hanging side by side upon the same circuit. With regard to the intensity of the light, it is claimed that each lamp is equal to 16 candles, or to give more light than an ordinary 4-foot burner. While it was not in my power to make careful comparative tests, I am not sanguine that such lights as I saw illuminating the laboratory at Menlo Park will be found equal for general illuminating purposes to an ordinarily good gas burner. The light from the best lamps is certainly very bright when you *look at it*, but the simplest test of its illuminating power is to turn your back upon the source of light, and look at the space brightened by its influence. This trial I found to be an effective check upon any rising enthusiasm in regard to the illuminating value of the light, as compared with a good gas burner. The difference in this respect between the ordinary gas jet and the carbon horse-shoe light seems to me to be tersely expressed in the vulgar phrase, that the Edison light is "too thin," *i. e.*, while the light from the gas flame proceeds from a large quasi-solid body of luminous particles of carbon, the light from the carbon horse-shoe proceeds from *a very thin filament;* it is as though you should cover a gas flame with a little screen which would reveal merely a narrow rim of light; of course the illuminating power of the gas flame would be greatly decreased unless the incandescence of the narrow edge could be increased to a corresponding degree.

The machine of Mr. Edison generates a current of *very high electromotive force, i. e.*, of high tension and small quantity, this permits the use of small conducting wires, and I confess I was not a little surprised to find that the whole current required to heat the incandescent lamp could be conveyed through a copper wire no thicker than a horse-hair.

It appears to me that Mr. Edison, while using the same materials and similar apparatus to that of his predecessors, has in point of fact

made quite a new departure in the employment of a new form of a familiar material which thus offers, *in a short circuit*, an enormous resistance (100 ohms) in conjunction with a current of sufficiently high tension to overcome that resistance with the smallest possible sacrifice of power, thus really discovering a new path through a field which had already been prospected by numerous explorers. Whether this "lead" reveal a mine of wealth or prove to be a mere *ignis-fatuus*, I will not venture to predict.

The Secretary, exhibiting one of Mr. Edison's lamps [sent to the Institute by Mr. Addison B. Burk], called upon the latter for a few remarks.

Mr. Burk, in response, said that he feared he could add little to the admirably clear description of the lamp and generator given by Mr. Outerbridge. Having visited Menlo Park several times, however, he could say that Mr. Edison had certainly produced a lamp fitted, if it should have lasting qualities, to take the place of gas.

At present Mr. Edison is experimenting with lamps of different resistances to determine what resistance is best suited for his purposes. As a result, some of the lamps now exhibited give forth a light much below and others above the candle power of a gas jet. When the light is dim, the carbon filament is of high resistance, and appears as a reddish-orange line within the globe; but in lamps of low resistance, where the carbon is raised to a white heat, the source of the light disappears, and the globe appears as a ball of fire.

Prof. Rogers inquired whether the speaker thought that the dimness of two lamps near the station, mentioned by Mr. Outerbridge, was due to their distance from the generators.

Mr. Burk replied that he thought the distance from the generator had nothing to do with it, but that these were simply lamps of high resistance. Within a few yards of the lamps at the entrance to the Park there is an exceptionally fine lamp. In Mr. Upton's parlor some of the lamps close to the generator are no better than lamps at a distance. [Mr. Burk has since ascertained that the real trouble with the distant lamps was that the current was furnished to them through conductors too small for the purpose. New lines have been laid, and the most distant lamps are now as bright as others of the same resistance elsewhere in the circuit.]

In answer to other questions, Mr. Burk said that many difficulties

had been met with in the manufacture of the lamps. A record is kept of the life and death of each lamp, an inquest being held whenever a lamp fails. Mr. Edison was recently reported to have said that 22 per cent. of the lamps failed. Mr. Burk, from his hasty examination of the records, judged that there had been fully that many failures with lamps actually put on the circuit, while there were very many lamps that never got beyond some one or other of the stages of manufacture. The causes of failure were numerous. Some of the lamps exploded or collapsed, probably because they were not strong enough to withstand the air pressure. In others, the inner bulb cracked after the lamp was lighted. Mr. Burk had watched the boys putting the platinum wires through the inner bulbs, and had noticed that sometimes when the direction of the wires did not suit them they would bend them over, thus probably putting the glass under strain. When heated under such conditions, cracking might be anticipated. This accident had occurred to the lamp shown at the Institute, in which the inner bulb was cracked in a straight line between the two platinum wires as they passed through the bulb. Some of the exploded lamps left behind them parts of the carbon horse-shoe. One of these had been examined by Mr. Burk under the microscope. It did not appear very different from the carbonized paper before being made incandescent, but had a higher lustre—was more metallic-looking. There was another supposed source of failure, and that was the leakage of air through the top of the bulb, where it is sealed. Mr. Edison had noted the fact that a much larger percentage of the lamps set in fixtures failed than of those hung upside down from wires. He therefore examined the seal, and saw, or thought he saw, a minute crack. He then examined some of his vacuum apparatus, similarly sealed, and found a similar supposed defect. Mr. Edison calls all difficulties "bugs," and this "bug" he got out of his lamps by adopting a new method of sealing. Conceiving that the difficulty might be in making a perfect seal in vacuum, he first sealed the tube as usual, and then admitting the air to the sealed tube sealed it again, imprisoning a small globule of air between the first and the second sealing, but obtaining clear glass around all. He thought that without this second sealing (which is done in many different ways) the crack which he found in some of his lamps might be sufficiently expanded by heat to admit a little air to the lamp, and thus destroy the vacuum.

Doubts had been expressed whether the lights furnished by Edison's

lamps were equal in power to a gas jet. Mr. Burk thought there was no doubt that some of them had a higher, as some had less candle power. He had seen experiments tried in the reading of newspapers which satisfied him on this point. There was certainly no difficulty in making the carbon give forth a light much greater than a gas jet. The whole current had been turned on one lamp [that is, all other lamps had been disconnected], and it gave forth the light of many gas jets. In Mr. Upton's parlor there is a central light hung from the ceiling that illuminates a large room much better than the speaker had seen similar rooms in Philadelphia lighted by three gas jets. But the best evidence that the light was a fair equivalent for that of gas was to be found in the fact that skeptics visited Menlo Park and came away refusing to believe that the lamps had sufficient illuminating power to take the place of gas, and yet these same skeptics would admit, on cross-examination, that they had eaten their suppers at Mrs. Jordan's, at Menlo Park, without noticing that the dining-room was lighted with two of Edison's lamps!

It is well known that the voltaic arc lamps, giving a light of say 2000 candles, cannot take the place of gas jets having the same candle power in the aggregate. The speaker doubted whether these large lamps would replace more than one-third of their candle power in gas jets well distributed. Mr. Edison claims that, while he may lose by a division of the current in the aggregate candle power obtained from a generator, he gains on the other hand by the distribution of his smaller lights.

Prof. Elihu Thomson said:

There seems to be little doubt that an incandescence electric lamp of moderate permanency is a mechanical possibility. Whether the lamp in question answers all the requirements in this case is of course for the future to determine. It would seem, indeed, that a consideration of facts long in the possession of electritians and others points to the construction of a practically permanent incandescence lamp as a possibility.

The earlier lamps were short-lived; those succeeding were more lasting. The element of permanency seemed to have been gradually introduced, and the results claimed by Edison point in the same direction. Whether any new departures have yet to be taken to secure a practically enduring lamp cannot as yet be determined.

The statement has been made and repeated, that Mr. Edison was

able to *turn the full current* of one of his generators on a single lamp without destroying it.

This is altogether an erroneous idea. The statement should have been that he was able to *take off* all the lamps but one from his machine, because from the resistance offered by this remaining lamp only such current could flow through it as its conducting power would allow.

The lamp was able to stand the whole electro-motive force of the machine, but not the whole current. In other words, the generator, with a single lamp in its circuit, did not *produce* more current than the lamp could easily stand.

There is, however, one phase of this subject that is vital; that is success or failure to lighting by incandescence: Does it pay? Can it compete with gas? And in this competition gas is to be regarded under its most favorable aspects, when most of the leakages are below ground and not above. Edison gets eight of his lights per horse power; but those who have not given attention to the subject will say: but when all the improvements are made may not sixteen per horse power be obtained? We say no; it is impossible to obtain sixteen lights of equal power to the eight, even with the best machinery and under the most favorable conditions. The reason is that the heat energy given out in the eight lamps, as at present used, nearly equals a horse power, and we cannot recover in the lights more power than we epmloy; not, indeed, more than 60 to 80 per cent. is recovered.

Eight lights per horse power seem to be all that are obtainable without lowering the candle power of each; but then comes the question, assuming eight lights per horse power attainable, what is their candle power? How much light do they give out? Opinions differ. Those who have seen the lights at Menlo Park must have been struck by their comparative feebleness. Their average candle power would appear to be from 8 to 10 candles. Taking the more liberal estimate, 10 candles, we get in the eight lights 80 candles, or 80 candles per horse power. Of course incandescence lights of any desired candle power can be obtained, but an increased intensity per light means a decreased number per horse power. Now, it is easily possible to produce by the voltaic arc from 800 to 1000 candles per horse power, or over 10 times that obtainable by incandescence.

Hence it would seem that the arc must be used in the lighting of large areas in preference to incandescence, even were the economy of

the latter over gas a proved fact. The cost of carbons in arc-lighting is not now of much consequence, as increased production has lowered the prices considerably. There seems, indeed, to be two fields of usefulness for electric lighting:

First, where large areas are to be lighted, or where a powerful white light is needed for special purposes, the arc light is a demonstrated success, and its cheapness is a recommendation.

Second, illumination of small areas, as in house lighting, to which lighting by incandescence would seem to be peculiarly adapted, but the success of which rests on the permanency of the lamp and the economy of power consumed, both matters which have not as yet been sufficiently determined.

Prof. Robert E. Rogers had noticed at Menlo Park the absence of photometric apparatus for determining the illuminating power of the lamps. His own impression was that the light did not in any case exceed one-half that given by a gas burner consuming five feet of gas per hour.

Mr. E. Brown had an impression similar to that of Prof. Rogers. A new lamp which had just been put into operation did not equal a 5-foot burner; many of the lamps were much below that standard. While taking supper he did not notice for some time that the illumination was from the electric lamps—one being placed at each end of the chandelier, showing that the light resembled closely that from gas or oil.

Mr. Smethurst was of opinion that the light had a greater illuminating power than an ordinary gas light, and thought that reading by it was not a reliable test.

The Ultra-violet Spectrum.—Cornu has been led, by his spectral observations at different hours and in different seasons, to attribute an absorbing power to the atmosphere, so great as to exclude a large portion of the ultra-violet extremity from observation. In order to test his theory, he made observations upon the Riffel, at an altitude of 2570 metres (1·597 miles.) He found that the increase in the extension of the ultra-violet spectrum, expressed in wave-length, is only a millionth of a millimetre for 900 metres of increased altitude (·00000003937 inch for 2952·81 feet).—*Comptes Rendus.* C.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE GOODWIN MOWING MACHINE AND THE NEW MECHANICAL MOVEMENTS EMBODIED THEREIN.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, December 31st, 1877.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the Goodwin Mowing Machine and the new mechanical movements embodied therein, report that this machine consists of a right-angled triangular cast iron framing, hanging at its short side upon and swinging about an axle which revolves in self-adjusting roller boxes, encased to form oil receptacles and be protected from dirt. The driving wheels running loose upon this axle are below the usual size of such wheels, and have upon their peripheries numerous lugs or spuds to secure traction.

Motion is communicated from these wheels to the axle by means of internal ratchets, upon the inside of their rims, which engage with pawls upon the end of the arms firmly secured to the axle, whereby the forward motion only of the wheels is communicated to the axle, and through it to the operating parts of the machine, with but little loss of motion, an advantage that will be more apparent hereafter.

To the forward and acute angle of the main frame is secured the cutter bar, extending laterally just in front of the off driving wheel, and is joined to the angular frame by a peculiar hinge and lever, whereby the cutter bar may assume any angle from 45° below to 90° above the horizon, and be tilted so as to throw the guards down to the ground for the purpose of catching and raising down and lodged grass, or be thrown up to clear stones and rough ground.

The pole is attached to the main frame by a hinge, located back of and above the axle, whereby the frame and pole may take any required position relative to each other, so that in passing over undulating ground the horses may be on a raise and the cutter bar in a hollow, or *vice versa*.

The seat for the driver is secured to the pole upon a steel spring, fastened to the foot-board by a loose bolt and rubber, acting in such a

manner as to allow a lateral as well as vertical spring motion, thus relieving the driver of the sudden side lurches as well as the vertical jar.

The weight of the driver is thrown behind the jointed connection of the pole and frame, thus almost balancing the weight of the pole, and relieving the horses' necks from any unnecessary strain.

The jointed connection of the pole and framing, being back of the axle carrying the frame, and adjustable, the combined weight of driver, pole and whiffletrees are made to almost balance on the axle the main frame of the machine with its attachments, so that their combined weight is thrown upon the driving wheels, and the sliding shoes relieved from carrying any great weight, whereby lightness of draft and great traction is secured.

The near driving wheel is made about one-half inch smaller in diameter than the off one, thereby giving it a tendency to make a greater number of revolutions than the larger one, and consequently throwing the burden of the propelling force upon it, which counterbalances the resistance to the cutter bar in the grass, thus almost entirely avoiding the tendency to side draft. So nicely are these forces, together with the weight of the driver and pole, balanced, that the latter may be taken from the yoke and the machine continue its work almost as steadily as before.

The draft link, connecting the whiffletree to the frame of the machine, is secured to the frame by an arm projecting below the axle, whereby a lifting tendency, in proportion to the draft or resistance at the cutter bar, is imparted to the forward end of the frame, and relieves it of the downward thrust at the cutter bar and the upward thrust at the axle, whereby the draft is lessened and the traction increased.

The power necessary to hold back, or to back the machine, is applied at the yoke and through the pole to the main frame; but, as the pole is secured to the frame by the hinge located above the axle, the power necessary to back the machine raises the forward end of the main frame together with the cutter bar, thus clearing all from the ground in backing, and enabling the machine to be backed over the cut grass without catching it up or clogging the machine.

The cutter bar, with the forward end of the main frame, may be set and held at any convenient and desired distance or angle from the ground, so as to cut a higher or lower stubble, or raised to clear

obstructions, independent of the tilting of the guards, whereby the down grass is raised.

The guards are secured to the cutter bar at an angle with its surface, so that when the grass is cut and passes over the bar it has an inclined plane to slide upon, whereby much of the crowding forward of the cut grass is prevented—a serious difficulty, we believe, in all other machines when cutting "lodged grass."

When it is desired to move the machine from place to place, the cutter bar is raised to a perpendicular position, and secured by a notch in the adjusting lever, and the main frame hooked to the pole, when the flexible parts of the machine become rigid and entirely clear of the ground, thus enabling the machine to be driven, as a sulky, from place to place. All of these changes in the machine are easily and quickly made by the operator without leaving his seat or stopping his team, and render the machine exceedingly convenient for mowing around stumps, rocks and over rough ground. The *reciprocating motion* for the sickle is obtained by what the inventor calls a "*reciprocating screw*," a mechanical term, the correctness of which was at first seriously questioned by your committee, but, upon a closer analysis of the construction of the device, we are compelled to accept this term as a correct one.

This "*new mechanical movement*," as the inventor also calls it, is a device that is very simple in its construction and operation, and seems particularly adapted to the requirements of a mowing machine. The female or nut portion of this movement consists of two discs bolted together, the inner surfaces of which are made with radiating angles or corrugations, the number of which correspond to the number of vibrations desired to be obtained from one revolution. The faces of these angles have the shape peculiar to that of the sides of the thread of a screw, that is, the angle increasing as the diameter diminishes. Both sides of the angular projections would be exactly represented by sections of a many threaded and right- and left-handed screw.

These discs are secured together by projecting flanges, thus forming a casing, and arranged relative to each other, so as to leave the points of the screw sections inside some distance apart, between which works the male or "bolt" portion of the screw.

This "bolt" consists of a disc having similar corrugations or sections of right- and left-handed screws upon either side, corresponding to the nut or casing in pitch and number of threads, and is

secured to a sleeve, working over the shaft and through one of said discs, whereby its reciprocating motion may be communicated outside of the casing.

This casing is secured rigidly to the driving shaft and rotates with it.

The internal disc or bolt has upon its sleeve trunions, working in the lever which moves the sickle bar.

As the nut or casing revolves, the bolt or disc is unscrewed from the right-hand thread of one side into the left-hand thread of the other side.

When it has reached the full length of this section it meets the right-handed thread upon the other disc or nut, and is forced back, entering the left thread upon the first disc; thus a constant reciprocating motion is obtained, the number of throws to one revolution depending upon the number of threads in the screw.

In the case before us thirty-eight strokes are obtained by one revolution of the main wheels, without the use of spur gears for getting up the quick rotary motion, mitre or bevel gears for turning the motion at right angles, as is required in mowing machines, and the crank and pitman for converting the rotary motion thus obtained into reciprocating.

The connection between the lever and the sickle bar is a link, with ball and socket joints, and allows of the free adaptation of the frame and cutter bar to the undulations of the ground.

From the fact that the sickle receives its motion from sections of screws, the motion is uniform throughout the whole length of the stroke, thus presenting a uniform and almost continuous cutting motion to the grass, whereby the cutting is done without allowing time for the grass to bunch in the guards, as is the case in machines where the sickle is operated by a crank.

The abrupt reversing of the motion of the reciprocating parts in this machine at first presented itself to us as a serious difficulty in this movement, but upon a close examination it appears that the vibrating disc or bolt cushions the air between it and the nut or case, and their surfaces so nicely coinciding with each other, and being of so extended an area, the momentum is taken up and overcome in a very great degree by this air cushion.

The casing of this movement, being fitted together oil-tight, becomes an oil receptacle, into which a considerable quantity of oil may be

placed, when by its revolution every part of the working surfaces are submerged in oil.

The wearing surfaces are so large that the oil appears to prevent the actual contact of the metals.

One movement, on examination after use in cutting many acres of grass and millet, showed but little signs of wear; that seen was scarcely perceptible, the sand marks still being on the cast wearing surfaces.

This condition of things is evidence of but little friction in this movement.

Field Tests.

Your committee made quite a number of field tests, in some of which five other machines of different manufacture, representing the leading machines of the country, were tested in comparison with the Goodwin reciprocating screw machine.

All the machines were good samples of their kind, and were put in good order by one man, who was employed for the purpose, and believed to be disinterested and impartial.

The same team was used for each machine during each test, and each machine operated by, we believe, impartial and experienced persons throughout each set of trials.

The instrument used in the early field tests was one of Fairbanks' non-recording dynamometers, which proved unsatisfactory on account of the great discrepancies in the readings by different persons, when it was resolved that five persons should record the draft as indicated, and the average of the whole be taken as correct.

This also proving unsatisfactory, both to your committee and to the parties in interest, a self-recording dynamometer was invented and constructed expressly for the purpose, recording on a continuous moving paper all the variations of draft and working, with all the delicacy and precision desired.

The field tests were numerous and varied, being made over great varieties of ground, from the well-kept lawn to rocky, rolling land; from heavy swamp grass to dry hillsides, covered with last year's dead grass and the growth of the present year; from the short matted park grass to millet 5 feet high, through ditches and over rocks into washed soils.

Terraces at an angle of 45° were mowed, both from the top downward and from the bottom upward.

Altogether, the machines were, in the opinion of your committee, put to a more severe test, and a greater variety of work, than they would encounter in many years' use on the farm.

The mechanical tests were:

1st. To test the traction of the wheels upon the ground with their ordinary load.

2d. The power applied in draft to overcome an increasing resistance upon the sickle bar.

3d. The power lost by friction in converting "slow rotary" into "quick reciprocating" motion under a constant resistance, also under an intermitting resistance.

4th. The draft power required to cut off between the cutters and guards various sizes and kinds of woods.

5th. The weight thrown upon the yoke, or horses' necks, under varying draft strains.

6th. To get an exact diagram of the movement of the sickle as the machine passes over the ground.

To ascertain the above facts, strains and resistances, special apparatus was constructed.

One test consisted of a given weight, moving through a given space, suspended from the driving wheels, producing a given motion to the sickle bar, under constant and under intermitting resistances, for which a specially devised and constructed instrument was used.

The non-recording dynamometer and spring balances were tested each by the other, and by weights, and were found to correspond very closely throughout the whole scale.

The recording dynamometer required considerable force to overcome the friction of the recording device which tended to steady its movements while this resistance was counted and recorded in the log.

To ascertain the precise movements of the sickle in cutting grass, as the machine traveled over the ground, a recording instrument was attached to one of the sickle sections, recording its movements on paper as the machine moved in its usual course over the ground.

These diagrams will be found with the other records herewith submitted.

All the machines were tested by the same instruments, taken immediately from one machine to the other without change.

To give in this report all the data and figures obtained from field

and mechanical tests would render it voluminous, and a mass of unintelligible notes and figures, incomprehensible to the general reader.

Your committee has therefore deemed it best to submit herewith a copy of the log,* and give only the result in percentages and degrees, and invite those desiring more of the details to glean them from the records themselves.

From the data and facts obtained, and our observation and use of the various machines, your committee have arrived at the following conclusions relative to the *Goodwin Mowing Machine:*

1st. For ease and comfort to the driver it stands first.

2d. For convenience of manipulation in the field, cutting over and around obstructions, it stands first.

3d. For cutting over uneven or undulating ground, over ditches and steep terraces, it stands first.

4th. For mowing wet swampy bottoms, through swamp and wet grass, it stands first.

5th. For raising and cutting down grass, for cutting close and even stubble of uniform length for lawn or parks, it stands first

6th. For cutting high, heavy and lodged grass, it stands first.

7th. For power to cut large weeds of woody growth, bushes, etc., it excels all others tested by about one hundred per cent.

8th. It is the only machine examined, or known to your committee, that will raise its cutter bar and framing, and clear the cut grass in backing from its cut.

9th. For the absence of side draft it stands first. It is the only machine known to us that is free from it.

10th. It is the only machine known to us that is free from unnecessary weight on the yoke, or horses' necks, under varying draft strains.

11th. For lightness of draft while running all its parts, without cutting, it stands first.

12th. For durability of wearing parts it stands first.

13th. For economy of construction it stands first.

14th. In point of noise in running it stands third.

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* A brief summary of the log is herewith appended.

The Mechanical Movement as a Device for Converting Slow Rotary into Quick Reciprocating Motion, of Uniform Velocity.

For the application of this device to various uses your committee are of the opinion that its application is limited to those uses where but light parts are to be reciprocated and the source of power slow and rotary, and a uniform motion is desired through the whole length of the stroke.

The abrupt cessation of the motion in one direction, and its instant starting at full velocity in another, renders it unfit, in our opinion, for general use or for heavy moving parts.

Its embodiment in a mowing machine seemed to us to be a most happy application of this new mechanical movement.

The requirements of the movements in mowing machine sickles are arbitrary when the best results are to be obtained, and this device seems to fill them most admirably, converting the slow rotary motion of the driving wheels into quick reciprocations in a direction parallel to the axis of rotation.

Its uniform motion keeps the sickle cutting the grass with the minimum resistance or quantity of grass at a time, and prevents "bunching" of the grass between the guards, a serious objection to the crank movement, bunching taking place during the time the crank is passing the centres.

1st. For simplicity this movement stands first.

2d. For durability it stands first.

3d. For economy of power it stands first, one test showing that the ordinary crank and gearing required over one hundred per cent. more power than this movement did to do the same work.

Considering the many difficulties to be overcome in adapting machinery to the varied conditions under which agricultural machinery generally is required to work, and especially harvesting machines, and remembering how thoroughly and practically the inventor of this machine has accomplished this, your committee are of the opinion that no award at the disposal of the Institute is too great for such a victory.

We therefore recommend that the Franklin Institute award to Wm. Farr Goodwin "the Elliott Cresson gold medal" for his mow-

ing machine, and the SCOTT'S LEGACY PREMIUM and MEDAL for the new mechanical movement contained therein.

Respectfully submitted.

CYRUS CHAMBERS, JR.
W. BARNET LE VAN.

Approved Feb. 6th, 1878.

MOWING MACHINE TEST.

Brief Summary from Log Book, for convenience of Reference.

First practical field test. Horace J. Smith's field. Lowest average drafts by the non-recording dynamometer, one person, only, calling the figures.

Buckeye Machine.

Draft, empty, down grade,	.	80·3	pounds.
" " up "	.	125·	"
" cutting high stubble,	.	164·74	"
" " low "	.	191·10	"

Clogged four times in cutting two swaths. No. 1.

Worm-wheel and Screw Machine.

Draft, empty, down grade,	.	118·75	pounds.
" " up "	.		
" cutting, down "	.	209·82	"

Champion Haymaker Machine.

Draft, empty, down grade,	.	91·78	pounds.
" " up "	.	123·68	"
" cutting, down "	.	245·45	" No. 4.

Little Giant.

Draft, empty, down grade,	.	105·	pounds.
" " up "	.	117·	"
" cutting, down "	.	204·46	" No. 2.

Goodwin's Reciprocating Screw.

Draft, empty, down grade,	.	127·77	pounds.
" " up "	.	172·91	"
" cutting, down "	.	205·88	" No. 3.

Second public field test. Dr. Heenan's field. Non-recording dynamometer; five persons recording, and the average of all taken as correct.

Reciprocating Screw.

Out of gear,	75 pounds.	
In gear, running empty,	87 "	
" cutting fine grass,	162·5 "	No. 1.

Champion Haymaker.

Out of gear,	80 pounds.	
In gear, running empty,	104 "	
" cutting, 2 drags,	185 "	No. 2.

Buckeye.

Out of gear,	83 pounds.	
In gear, running empty,	103 "	
" cutting,	191 "	No. 3.

Worm-wheel and Screw.

Out of gear,	88 pounds.	
In gear, running empty,	118 "	
" cutting,	191 "	No. 4.

Third public field test. George's Hill. Self-recording dynamometer; average taken from the card.

Worm-wheel and Screw Machine.

Not cutting, but in gear, average,	154 pounds.	
Cutting fine park grass (half dead),	215 "	No. 4.

Champion Haymaker.

Not cutting, but in gear,	180 pounds.	
Cutting same grass,	246 "	No. 5.

Buckeye.

Not cutting, but in gear,	140 pounds.	
Cutting same grass,	211 "	No. 3.

Goodwin's Reciprocating Screw, New Pattern.

Not cutting, but in gear,	189 pounds.	
Cutting usual height and same as others, and in same grass,	210 "	
Cutting ¾ inch lower,	247 "	No. 2.

Goodwin Reciprocating Screw, Old Pattern.

Not cutting, but in gear,	154 pounds.	
Cutting same grass,	208 "	No. 1.

Friction test under normal load. Public test on Horace Smith's lawn.

Buckeye slides at 750 pounds with both wheels. No. 3.

Goodwin's Reciprocating Screw slides at 500 pounds with one wheel, with 250 pounds resistance; but dynamometer would not measure the draft strain at the cutter bar for both wheels, it being limited to 1000 pounds. No. 1.

Champion Haymaker—both wheels slide at 650 pounds. No. 4.

Worm-wheel and Screw—both wheels slide at 800 pounds. No. 2.

Butyric Ferment in the Coal Period.—Van Tieghem has studied some of the vegetable fossils in the Belgian coal, for the sake of comparing the changes which they have undergone, with those which take place at the present day. If fragments of the young roots of yew or cypress are left for some time covered with water, the *Bacillus amylobacter* is developed, attacks most of the tissues and completely dissolves the cellular membranes. In the bark, all the ordinary parenchyma, then the layers of cellular tissue, and finally the endoderm, gradually disappear, only leaving at the surface the summits of the epidermic cells which form the cuticle. In the central cylinder the root-producing layer and the conjunctive tissue are destroyed, only leaving the central band of vessels. The cellulose is decomposed as fast as it dissolves, and undergoes the butyric fermentation. At the same time the amylobacter leaves visible and direct traces of its development. The same progress in the destruction of the tissues is observed in the coal, leaving as a final result only the cuticle and the vessels. There are also the same visible and direct traces of the development of the amylobacter in the interior. We may, therefore, conclude that in the marshes of the coal epoch, as well as in those of our own time, the same plants underwent, in the same portions of their tissues, the same dissolution by the same agent. Then, as now, the *Bacillus amylobacter* was the grand destroyer of vegetable organisms, and the butyric fermentation which it excites was displayed as one of the most general of all organic phenomena. Pasteur's investigations of this ferment find in these facts a new application, which will be fruitful in palæontology.—*Comptes Rendus.*

SAWS.*

By Robert Grimshaw, Ph.D.

[Continued from January issue.]

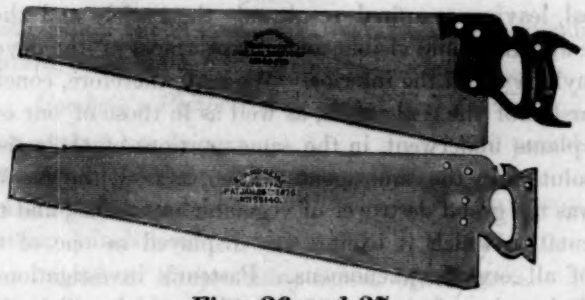
Class 4, free at one end, and "push cut" is perhaps the most numerous of all—including principally all the varieties of carpenters' hand saws, of both parallel and taper blades, with and without backs.

In general, the teeth are of equal size throughout the length; but there is in some varieties—notably the hand-rip-saw—an increase in the size of the teeth from point to heel, referred to at the close of the remarks on saw teeth. But this increase is not always regular and graduated, being sometimes a sudden step.

This class may be subdivided into (*a*) taper saws, without frames, and (*b*) parallel saws, with backs. The following table gives lengths, sizes and spaces of teeth, etc.:

	Name.	Length.	Gauge.	Points to inch.
Taper.	Hand,	26″	19	5 to 12
	Rip,	28″ to 30″	18	Heel, 3 to 5; Point, 6 to 8
	Panel,	14″ to 24″	22 to 20	8 to 12
	Compass,	10″ to 20″	16	——
	Keyhole,	7″ to 9″	21	——
Backed	Tenon,	6″ to 18″	22 to 20	11 to 15
	Miter,	20″ to 30″	20 to 19	10 to 11

The *rip*, *half rip*, *hand*, *broken space*, *panel* and *fine panel* are alike in general appearance. *Chest* saws are merely diminutive thereof.



Figs. 26 and 27.

* Extracts from "Grimshaw on Saws." 160 pp. Royal 8vo. Philadelphia: Claxton, Remsen & Haffelfinger. 1880.

The blade is "taper" in order that it may be nearly equally stiff throughout; for ease in attachment of the handle, and to lighten it. This taper is either straight or curved.

The curved taper (Fig. 28) is claimed by the makers to somewhat lighten the saw, while lessening its liability to vibrate when drawn from a cut. The "increment" tooth of the rip saw is clearly shown in the figure.

Figs. 26 and 27 show a mode of strengthening the handle.

The *table* saw and the *compass*, or *lock* saws, differing only in size, and all used for curved line cutting, have narrow blades to permit their turning sharp corners.

The *keyhole* or *lock* saw is the narrowest. It should be made with a pull cut for the reasons stated, page 32.

Pruning saws are coarser, thicker and keener than those for dry wood. They are sometimes made with half moon or briar teeth for rapid execution.

The pond ice saw, generally supplied with a "tiller handle," is 7 to 8 inches wide at butt, 5 to 6 inches at point, and 9 to 10 gauge.

Hand saws for ice are about 24 inches long, gauges 16 and 18; teeth regular cross-cut pattern, ½ inch to 1 inch apart and deep, and with enormous set as this material clogs greatly.

Fig. 28. "Skew Back" or Curved Taper Rip Saw.

The various *backed parallel bladed saws*, known as *tenon, sash, carcase* and *dovetail*, according to their uses, have thin and carefully hammered blades stiffened with a piece of metal sprung on. They are much employed for accurate work. Care should be taken not to spring the back by knocks.

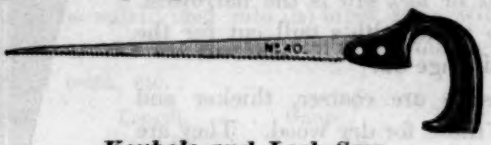
The *smith's screw head saw* has a handle like a file and is used for cutting the slots in screw heads. It has a thick and hard blade.

The comb cutter's saw, sometimes called a "stadda," is double, the

two blades being separated by packing, at any desired distance; one edge being slightly in advance of the other so as to enter a new cut, which the other finishes. Thus spacing and depth are preserved equal.

Fig. 29. Miter-box Saw.

See Fig. 30. Similar saws, on a larger scale, have been used for cutting microscope and air pump racks.



Keyhole and Lock Saw.

The increment tooth (see page 35) has these advantages for hand-saws: the fine teeth being used to start the cut and coarse ones to finish, a saw will work freely and easily. In hand-sawing the least

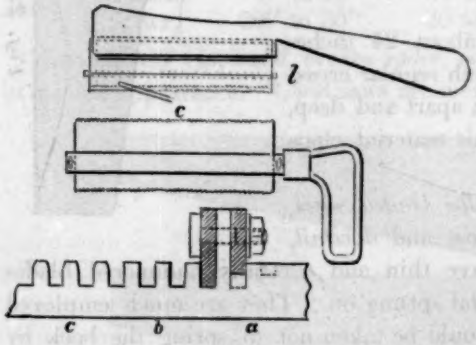


Fig. 30. Comb Cutting Saw.

Fig. 31. Adjustable-Backed Saw.

Fig. 32. Rack Cutting with Saws.

amount of power is employed at the beginning of the cut, but as the arm straightens at the elbow more force is used, and the coarser teeth allow it to be utilized because the space between the teeth

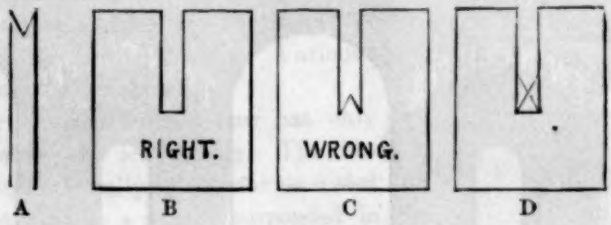
do not clog as readily as the fine teeth do, and the fine teeth do not catch at the beginning of a cut as do coarse teeth.

The teeth of a hand saw should be so truly filed that on holding it up to the eye and looking along its edge lengthwise it should show a central groove down which a needle should slide freely. See Fig. A.

The cutting action should be such that the bottom of the kerf should present the appearance of Fig. B, and not that shown in Fig. C.

Fig. D shows the proper cutting action of the teeth.

Saws free at one end and cutting on both strokes are comparatively rare. The M teeth hand saws and some butting saws mounted as drags, are all that we call to mind.



Class 6, strained in a sash, guided at both ends and cutting on both strokes, is a peculiar one. We call to mind but one representative—Robinson's horizontal veneer saw, shown at the Paris Exposition of 1878. Very peculiar inclined guides give the blade what would correspond to overhang on each stroke, so as to give lead both ways.

Class 7 is the *pit saw*, practically the single sash, unguided and worked by hand. The blade is from 5 to 8 feet long.

Class 8 includes the "cross-cut"—frequently written "× cut." They vary largely in general appearance and in disposition, but have always for their object the severing each fibre in two places.

They are made double as wide in the centre as at the ends—to stiffen the blade and to allow for the greater amount of wear in the centre. The "gains" or gullets in the centre are often made twice as deep as those at the ends, to save frequent "gumming."

In general there is one set of teeth termed "*scorers*," which sever the fibres at the sides, and others called "cleaners," which remove the central core or ridge, and blow out the dust made by the others. Cross cutting is like scoring a "gain" in a plank with the edges of a chisel, and then with the flat edge removing the severed portions.

"Cleaner teeth," "clearers," or "plows," are made slightly shorter than the cutters with which they alternate.

In the "Twin Clipper" (see cuts) there are two M's, or four teeth to a section; one M, or two teeth, set each way. The maker claims that where there are but two teeth (or one M) in a section, both teeth set the same way, their tendency is to draw towards the point and first take to the side of the kerf and draw or spring the section over until it lets go when it reacts, cutting the sides of the kerf wavy, in this manner.

In this cross cut one pair of teeth is designed to counteract the

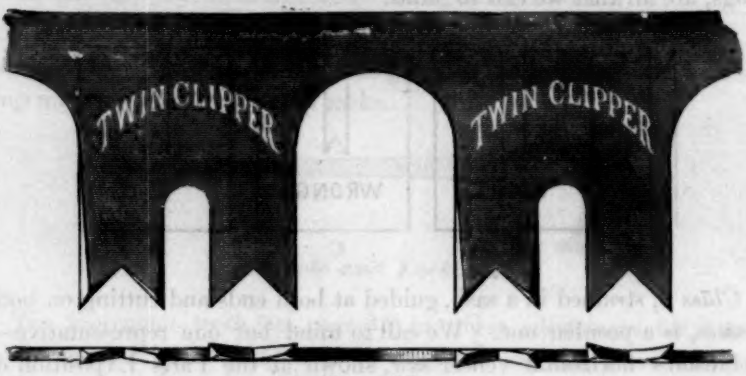


Fig. 33.

spring of the other, keeping the section straight and unsprung. It is also claimed that when a section has but two teeth it cannot be as stiff as with four.

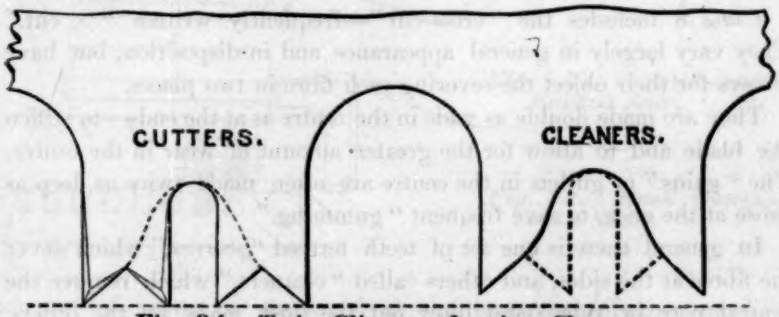


Fig. 34. Twin Clipper, showing Cleaners.

The cleaner teeth of the "Twin Clipper" (see Fig. 34) are made by simply cutting out the inside section of two teeth, as shown by the dot-

ted lines in the cut—leaving two sets of cutting teeth or scorers between each pair of clearers, which are about $\frac{1}{32}$ inch below these last.

The teeth of solid cross cuts are difficult to keep of proper length and shape. The saw requires frequent gumming, and in this process is frequently broken or sprung and kinked, and then, unless hammered and straightened by a skilled hand, will be sure to give trouble by running hard and sticking in the log. The perforated cross cut avoids gumming, and the teeth are easily kept just right.

Fig. 35. Disstons' "Great American."

Fig. 35 shows part of a cross cut, in which the notch of each M is followed by perforations, as also are the larger gullets between the Ms and the Ws. Various styles of cross cuts are shown.

The Weight Strained Saw has only one application—to ice cutting. The blade is mounted vertically in a frame on a sled and is kept taut by a weight suspended in the water to the lower end. Arctic explorers use this saw for cutting their ships out of ice floes; and it has been used for heavy ice-cutting for commercial purposes.

The Spring Strained Saw, commonly known as the Gig, Jig, Fret or Scroll Saw, has a pull cut only; the return being effected by the same means that keeps it strained. It is light running and generally used for cutting out fine curved or scroll work; although of late years the band saw is superseding it for outside work.

Jig sawing really divides itself into two branches—sawing in irregular shapes on the outside of a piece of material, and the same process on the inside, known as fret work.

The short and readily detachable blades of the strained jig saw can be so quickly withdrawn from one cut and inserted in another starting hole that the band saw has no chance to enter the field of fret work.

It may be said to have influenced American architecture, which seems largely to have been arranged so as to give every opportunity

possible, from crest and barge board to porch and railing, for the display of scroll sawing.

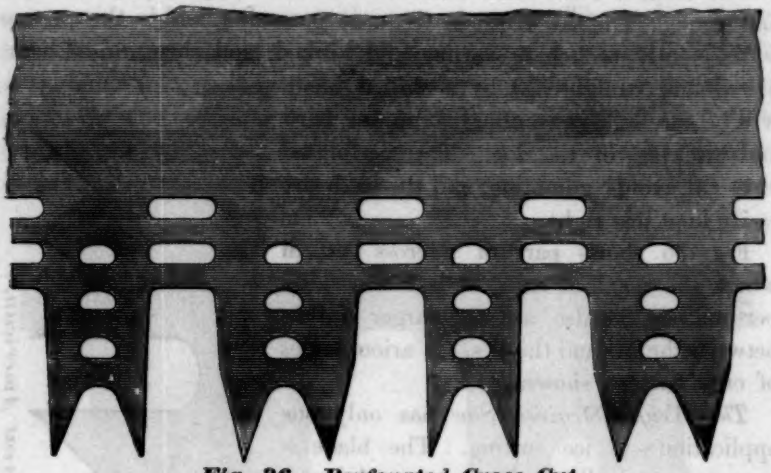


Fig. 36. Perforated Cross Cut.

Scroll-sawing blades are from 8 to 24 inches long and 13 to 16 gauge.

Fig. 37. Feather Edged Back.

We may only notice that most makers grind their jig saw blades at the back, to avoid all error of setting, while Andrews grinds to a feather edge (Fig. 37).

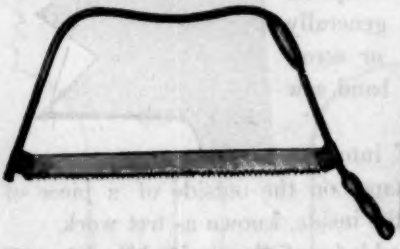


Fig. 38. Andrews' Steel Spring Buck Saw.

Fig. 39. Andrews' Bucksaw—Wood Frame, Steel Spring.

The larger sizes necessitate a blower to keep the kerf free from dust and enable the workmen to see the lines of the pattern.

The "Fleetwood No. 3" fret saw runs about 700 to 800 cutting strokes per minute. Faster speed is apt to heat the saw and burn the wood. Routers sometimes use a double-edged blade.

We hear of *round* saws for scroll work, but have not yet seen them.

The Buck Saw, or Wood Saw, is a familiar implement. It is made with the ordinary inclined V or hand saw tooth, and also with the double cutting M; the latter far superior.

American use has discarded the stick and twisted cord strainer.

In frames, recent improvements enable a much larger log to be taken in. Figs. 38 and 39 show Andrews' frames, where the straining is accomplished by a steel spring comprising a part or the whole frame.

Web saws $\frac{1}{8}$ inch and narrower have wide ends, in order to give strength at the holes.

(To be continued.)

Gold in Petroleum.—According to John Turnbridge, gold may be found in the ashes of crude petroleum and in the refuse of petroleum stills.—*Der Bergmann.* C.

Electric Discharge in Gases.—Warren de la Rue and H. W. Müller publish the following results: 1. For each gas there is a minimum of pressure which corresponds to the minimum of electric resistance. If the pressure is diminished below this minimum the resistance increases rapidly. 2. There does not seem to be any condensation or expansion of the gas in the neighborhood of the electrodes. 3. The discharge is accompanied by a sudden, momemtary expansion of the gas, which does not appear to be due to the mere heating. 4. The ratio between the pressure and the difference of potential necessary to produce the discharge between two plane surfaces, at a constant distance, can be represented by a hyperbola; the same is true for the difference of potential and the explosive distance when the pressure is constant. 5. Between points, under atmospheric pressure, the potential varies as the square root of the distance. With a constant pile of 11,000 elements (chloride of silver), the explosive distance varied inversely as the pressure, from 1.5 mm. to 15 mm. (·059 inch to ·5906 inch). 6. The electric arc and the stratified discharge in a vacuum appear to be modifications of the same phenomenon.—*Comptes Rendus.* C.

ON THE CONSTRUCTION OF DOUBLE BEAT POPPET VALVES.

By WILLIAM P. TATHAM.

The ordinary construction of these valves is shown in Fig. 1, in which the sectional lines representing the seats of the valves make angles of about 45° with the axis. The dotted lines in all the figures show in an exaggerated manner the effects of expanding the valve by heat.

The trouble with them is in making and keeping both valve seats steam tight, and to this end it is not unusual to cast the valves and valve seats at the same running, so as to have metal of equal expansibility, and to grind the valves to their seats when hot, *i. e.*, under working conditions.

The object of this paper is to exhibit a principle of construction which would secure the desired result, provided that the touching surfaces of valves and seats be portions of true cones, and provided also that the expansion of the valve throughout itself be uniform, and that the expansion of the seats throughout be uniform also, however much these two expansions might differ one from the other.

Under these conditions, it is only necessary that the imaginary apexes of the two cones of which the valve seats are portions should be at the same point. This will secure a tight fit of both valve plates to their respective seats, with different expansion.

Let *ABC*, Fig. 2, represent a section of a solid cone of brass fitting closely a hollow cone of iron, or less expansible metal. When heated, the brass cone would expand and become a larger but *similar* cone, a portion of it still fitting the iron cone and the rest projecting above it, as shown by the dotted line *bc*.

Again, let *ADE* be a section of another solid cone of brass, having the same apex as the cone *ABC*, and fitting in a hollow cone of the same iron as in the first case. When expanded by heat, the brass cone would fill the hollow cone as before, and the expansion would be represented by the projection outside, indicated by the dotted line *d e*.

Now, what is true of these solid brass cones is true of any portion

of them, and if we shape them into a valve, as shown by the shading, it will have the property required.

It follows, that if the cone of the top plate have its imaginary apex on a level with the bottom seat, that seat must be flat, as in Fig. 3.

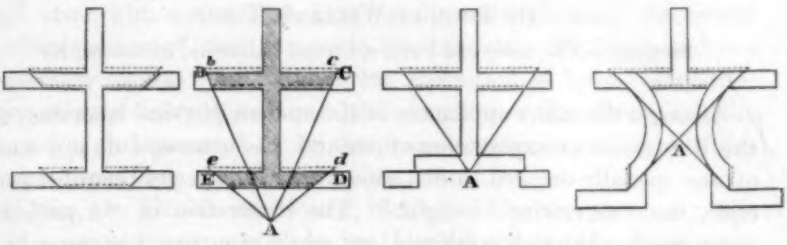


Fig. 1. Fig. 2. Fig. 3. Fig. 4.

If the imaginary apex be above the level of the bottom seat, then to make a common apex to the two cones the valve must take the form as shown in Fig. 4, which is very near to Hornblower's original double beat valve.

The same principle applies to the Cornish valve. The common apex may be considered as the point of no movement, every other part expanding radially therefrom.

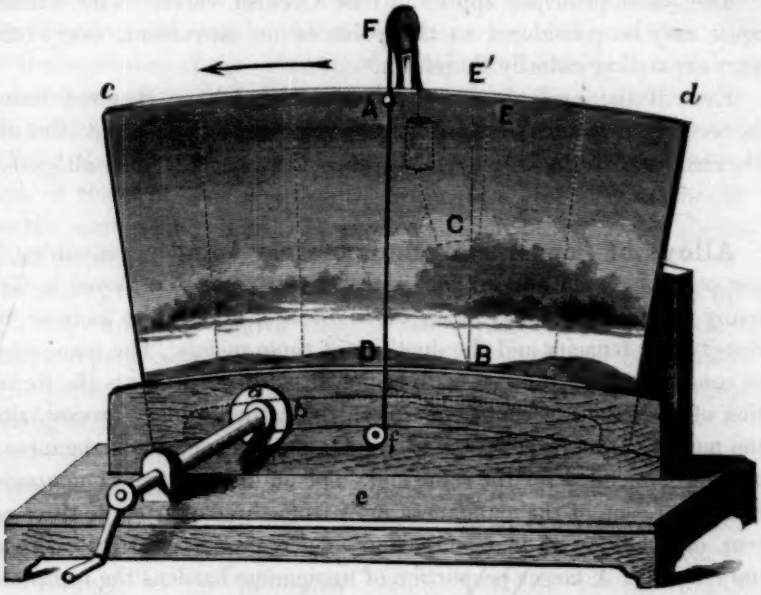
Even if the preliminary conditions which I have required cannot be secured, it would seem that a correct construction would diminish the chances of leaky valves, and perhaps do away with them altogether.

Alloys of Copper and Manganese.—An alloy, containing 70 per cent. of copper and 30 per cent. of manganese, is employed in Germany as an addition to brass or to bronze, in order to increase the density, the tenacity and the ductility of those metals. The manganese, in consequence of the ease with which it oxidizes, prevents the formation of the oxides of copper or tin which, in the ordinary process, alter the nature of the product. The employment of metallic manganese is also recommended for the same end. The addition of from one quarter to one per cent. of the manganese, or of from three-quarters to three per cent. of the alloy of manganese and copper, produces castings without blow holes. A larger proportion of manganese hardens the metal and gives to the bronze properties similar to those of steel.—*Bull. du Mus de l'Ind. de Belg.*

DESCRIPTION OF AN APPARATUS FOR ILLUSTRATING "THE ABERRATION OF LIGHT."

By THOMAS WILLIAM TOBIN,
Professor of Chemistry and Physics, Central University, Richmond, Ky.

Amongst the many appliances of the modern physical laboratory for the illustration or explanation of natural phenomena, I do not know of any specially devoted to that somewhat complex yet beautiful principle, the "aberration of light." The illustration of "a projected stone passing through a railroad car while in motion" is one only of comparison, and does not present satisfactorily the actual phenomenon to the mind of a student. With this fact in view, I constructed a piece of simple mechanism, which is actually a model of the reality, and the experiment having proved successful, I herewith append a description of it for general use:



The construction will be easily understood by reference to the accompanying diagram; *c d* is a movable disc in connection with the

pinion *a; b* is a grooved wheel on the same axle as the pinion, attached to which is a silk cord passing over the fixed pulleys *f* and *F*, thence to a counterweight at the back of the disc *c d; A* is a silvered glass bead on the silk cord; the whole is mounted on a stand *e*.

In the year 1725 Dr. Bradley, while making observations upon the fixed stars, with a view of finding parallax and distance, discovered the displacement of their images in the heavens. He explained in a satisfactory manner the cause in the aberration of light. By subsequent minute observations upon the character of the phenomena, this aberration was accounted for by the progressive motion of light, which he thus found to be 192,600 miles per second.

Römer, the Danish astronomer, had, some 50 years previously, also in an unexpected manner, determined the velocity of light, by observations of Jupiter's satellites, to be 192,000 miles per second.

Now, the apparatus already described is intended to explain how this velocity by Bradley was ascertained. Suppose the observer to be stationed at *B* and the earth stationary in space; the image of a star, a little to the left of the zenith, coming in the direction *E' B* would enter his telescope in that line. The velocity with which the image entered, great or small, would not affect the direction of the line of sight. Let now the image of a star at *A* be represented by the silvered bead, having a velocity *AD* per second of time; in other words, let the distance *AD* represent the velocity of light per second. While the image would appear in the line *AD* to an observer at *D*, if the earth were stationary, a very different result presents itself to the observer at *B*, when the earth has motion in the direction *BD*. Now, we will take *BD* to represent the velocity of the earth's motion in space during one second, and the mechanism of the apparatus will then show the progressive motion of the image *A* towards the observer at *B;* it will follow the dotted line *AB*. The arc at *C* represents the angle of displacement or aberration.

The problem of Dr. Bradley may be now easily stated: *DB*, the motion of the earth in space, was known; the arc *C* he ascertained by observation to be 20 seconds; the line *AD*, representing the velocity of light, he calculated by simple trigonometry to be 192,600 miles. It was one of the most interesting and important astronomical discoveries ever made, and confirmed Römer's previous discovery of the progressive motion of light.

On the Acid Products of the Combustion of Coal.

An essay read by Mr. Vincotte, Engineer-in-Chief of the Association of Bruxelles, Belgium, to the Meeting of the Engineers-in-Chief of the Association of Proprietors of Steam Apparatus, held at Lille, the head-quarters of the Association of the North of France, on the 9th, 10th and 11th of July, 1876,

Translated by Chief Engineer Isherwood, U. S. Navy.

The gases of combustion deposit on the heating surfaces of boilers different substances of great importance as regards the durability of the metal composing those surfaces and its power of transmitting heat. These substances are principally soot, tarry matter, sulphuric acid and ammoniacal salts.

The quantity of soot in the gases depends on the kind of coal consumed and on the intensity of the chimney draught, but whether great or small, a portion is always deposited on the heating surfaces.

The soot in immediate contact with the surfaces is cooled by them below the temperature of combustion, but when the deposit attains a certain thickness, the portion most distant from the surfaces burns whenever the hot gases of combustion passing over it contain sufficient free oxygen. The thickness of the soot deposit which escapes combustion depends on the temperature of these gases at any particular point considered, and should, therefore, after the boiler has been some time in use, be found to increase from the furnace to the chimney.

On all the heating surfaces where the gases of combustion have a sufficiently elevated temperature to burn the outer portion of the soot deposit, the unburnt inner portion is found covered with a white layer of ash from the burnt portion, and this ash has a thickness limited only by its cohesion; generally, it increses until the surfaces are swept.

On the heating surfaces where the temperature of the gases of combustion is too low to ignite the soot, the latter remains black and its thickness continually increases until it falls off by its own weight, which does not happen soon. The following are some examples:

1st. The case of a boiler with a feed-water heater. The gases of combustion pass first beneath the boiler and then return enveloping the heater.

The soot deposit has the appearance described below; I analyzed specimens from two places, one in the boiler at the end of the flue beneath it, the other in the heater not far from its chimney end.

On the boiler the soot formed three layers: one grey, passing insensibly into the second which was black; the third layer, under which the boiler iron was white, was formed of the white matter above described. On the heater there were but two layers; the outer one was greyish-black and the inner one was white at its contact with the metal.

Deposit from the Boiler.

	(1) Mixture of the two exterior layers.	(2) White substance in contact with the metal. Specimen taken beneath the preceding one.
Ferric sulphate and ferrous sulphate,	72·00	89·00
Ferric oxide and alumina,	18·00	0·00
Free sulphuric acid,	0·00	2·00
Sulphate of lime,	0·00	5·00
Carbonaceous matters,	5·00	3·00
Silica,	1·00	1·00
Water,	4·00	0·00
	100·00	100·00

Deposit from the Heater.

	(3) Exterior layer.	(4) White substance in contact with the metal.
Ferric sulphate and ferrous sulphate,	37·00	81·00
Ferric oxide and alumina,	3·00	3·00 (alumina)
Free sulphuric acid,	3·00	2·00
Sulphate of lime,	6·00	0·00
Sulphate of ammonia,	2·00	3·00
Carbonaceous matters,	22·00	0·00
Silica,	3·00	0·00
Water,	24·00	11·00
	100·00	100·00

The boiler and the heater had some very small leaks, passing probably only a few drops of water. Nevertheless, each leak was surrounded by a small cavity filled with iron rust and with calcareous

salts deposited from the water. I analyzed the products of this corrosion and obtained the following:

	(5) Leaks near specimens 1 and 2.	(6) Leaks near specimens 3 and 4.	(7) Leak in the heater.	(8) Leak in the heater.
Ferric sulphate, . .	6·00	65·00	0·00	4·00
Sulphate of lime, .	28·00	4·00	8·00	13·00
Ferric oxide and alumina,	65·00	24·00	23·00	77·00
Silica, ...	1·00	2·00	2·00	3·00
Carbonate of lime, .	0·00	0·00	67·00	0·00
Carbonaceous matters,	0·00	5·00	0·00	3·00
	100·00	100·00	100·00	100·00

If a piece of iron be plunged into a mixture of water and any one of the substances 2, 3 or 4, it will be violently attacked, with disengagement of hydrogen and formation of ferric sulphate. From this the inference is natural that a rapid corrosion of the boiler metal will be produced every time the soot becomes humid. The great variety observed in the products of corrosion depends on whether the leaks are of long standing or recent, and are probably influenced by different circumstances.

2d. The case of a boiler formed with two principal shells juxtaposed, and a feed-water heater.

On the two principal shells the soot formed the three layers above described. After the boiler had been some time out of use the appearance of the soot completely changed; it fell from the metal in the form of a shriveled skin, and the layers no longer continued distinct.

The exterior layer was analyzed at three different periods:

1st. Immediately after the boiler was put out of use.

2d. Some days afterwards.

3d. About a month afterwards.

The last two specimens, however, did not represent the pure exterior layer, for at the end of a month it could not be separated from the second one.

The specimen taken immediately after the boiler was out of use was white and very dry. It contained only traces of the salts of iron, and was composed principally of alumina and silica, with a little ammonia and a very notable quantity of sulphates of alumina and of lime.

The specimen taken after some time was pinkish-white and a little unctuous to the touch. It contained

Free sulphuric acid,	3·00
Ferric sulphate,	77·00
Sulphate of ammonia,	2·00
Sulphate of alumina,	5·00
Sulphate of lime,	3·00
Ferric oxide,	4·00
Silica,	3·00
Water,	3·00
	100·00

The specimen taken after a month had different tints of grey mixed with yellowish-green. It was unctuous to the touch, and had the following composition:

Water, by desiccation at 212° Fahr.,	36·1
Anhydrous sulphuric acid, calculated,	36·0
Ferric oxide,	20·7
Ammonia, alumina, bituminous matters, and water of combination,	7·2
	100·0

From the above it is probable that the exterior white layer contained neither free acid nor sulphate of iron during the time the boiler was in use, and that these substances were formed afterwards by imbibition when the two exterior layers became humid.

3d. The case of a horizontal boiler with two feed-water heaters. At the time of my examination it had been out of use a month, and the deposit on the heating surfaces of the boiler was in three layers.

On the exterior the substance was white, soft to the touch, and very light. Beneath was a blackish substance forming broad scales; finally, in contact with the metal, was a light layer of rust.

The black scaly matter melted by heat in its own water of crystallization, and had the following composition:

Sulphuric acid,	24
Ferric oxide and alumina,	37
Ammonia,	2
Silica,	3
Carbonaceous matters,	1
Water,	33
	100

The white matter contained

Sulphuric acid,	12
Alumina and ferric oxide,	54
Silica,	14
Organic matters,	2
Water,	18
	100

The corrosion is here seen in successive action.

The white substance immediately in contact with the metal has disappeared, and the rust, mixed with different salts, occupies its place.

The black layer contained ferrous and ferric sulphates; it has become hydrated and the salts have crystallized, giving the mass the appearance of black scales.

Along the lines of the rivets of the heaters were various leaks, which had strongly corroded the metal.

The white substance in contact with the metal has become transformed into a layer of rust, as always happens when boilers are out of use.

4th. The case of a boiler having interior furnaces, and in which the gases of combustion pass first through the flues behind the furnaces, then return through two flues by the sides of the boiler, and thence descending, pass in the original direction through a flue beneath the bottom of the boiler.

In 1873 the existence of large leaks in all the flues of this boiler was known. The whole of the metal was corroded to depths of from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch. The defective rivets were made tight; the leaks ceased, and with them the corrosion.

The deposit on the heating surfaces had the ordinary appearance. In the side flues the white substance in contact with the metal was very abundant, and had the following composition:

Anhydrous ferrous sulphate,	28
Sulphate of alumina,	17
Silica,	8
Alumina,	6
Water,	40
Metallic iron,	1
	100

The metallic iron came, without doubt, from the action of the chisel employed to detach the specimen.

The substance contained a great deal of water, nevertheless the metal was not rusted, which seems due to the fact that there was ferrous sulphate instead of ferric sulphate, the former being crystalline and dry notwithstanding the water it contained.

5th. The case of a vertical boiler with flat flues, heated exteriorly.

The examination took place three days after the boiler had been put out of use. All the heating surfaces were covered with a substance unctuous to the touch, and of a grey mixed with yellow and green color. A specimen taken from the flues at mid-height had the following composition:

Ferric sulphate,	41
Ferric oxide,	18
Sulphate of alumina,	9
Alumina,	9
Silica,	7
Sulphate of lime,	6
Water,	10
	100

The seams of this boiler showed some small leaks, which had deeply pitted the metal.

It is needless to here dwell on the disastrous influence which the soot exercises on the transmission of heat as soon as its thickness becomes sensible, and, consequently, on the necessity of frequently sweeping all the heating surfaces.

When fat coal is consumed only several days are required to form a layer of soot so thick that sweeping will not appear superfluous, but with the coal ordinarily used in steam boilers a much longer time is required, and a monthly sweeping produces marked effects.

Besides soot, the gases of combustion always contain a certain quantity of tarry matters in the state of vapors, which condense on contact with the heating surfaces and form upon them a layer of pitch.

With fat coal all the heating surfaces are sometimes found covered with pitch, but in general only those nearest the furnace are thus coated. The furnace surfaces have oftenest no other deposit than a thin layer of black pitch, which is useful in showing whether they have been overheated. In fact, it can be taken as a rule, even with

the lean semi-fat coal generally used, that the plates of the furnaces where no layer of pitch is found have been too much heated, either because of insufficient cleaning, or too much forcing of the fires.

There does not appear a satisfactory theory of the formation of the sulphuric acid. It may, indeed, be said that all the coals burned in boilers contain sulphur, whose combustion would naturally produce sulphurous acid, which encounters amid the gases of combustion free oxygen, aqueous vapor, and other substances necessary to its transformation into sulphuric acid; but what those substances are, or how they react is unknown. Be that as may be, it is found on all the heating surfaces not coated with pitch, and forms there in immediate contact with the iron beneath the soot a very thin layer of ferric sulphates, with which it remains mixed.

The quantity of acid thus found on the heating surfaces is so much the greater as their temperature is lower. It increases from the furnace to the chimney, and when the boilers are fitted with feed water heaters the acid is most abundant on them, where it is found not only in contact with the metal, but throughout the whole layer of soot there, which is impregnated with it.

Possibly the more or less sulphur in the coal may influence the quantity of acid which the heating surfaces condense. I have not yet had the opportunity of making a formal investigation, but at the first view the phenomenon presents itself rather as if, with all the ordinary coals, there always existed a great excess of acid, of which the heating surfaces condense as much as their temperature permits. The quantity of sulphur in the coal would then only have influence on the time required for the production of that amount of acid, and as in the circumstances necessary to be reproduced the acid and the iron remain in the presence of each other without combining, the percentage of sulphur in the coal would only have to be considered for the case in which the acid attacks the iron and constantly corrodes it.

To sum up, when a boiler is heated with semi-fat coal and examined after the fire is withdrawn, the heating surfaces are found covered with the following products of the combustion:

1st. Above the fire is a thin layer of very dry pitch mixed with soot, and ordinarily a little acid and astringent; if, however, portions of the surface have been overheated the pitch will have disappeared from them. Upon the pitch is some clinker, derived from the ash

mechanically carried up, which, being intercepted by the rivet heads and other projections, is partially fused there.

2d. Farther on are found three very distinct layers. The first, in immediate contact with the iron, is thin and white; it is composed of from 80 to 90 per centum of ferrous and ferric sulphates, 2 to 3 per centum of free sulphuric acid, a small quantity of ammoniacal salts, sulphate of lime, etc. Under this layer the iron is white and clean; sometimes it is brilliant.

The next layer is black soot mixed with a little acid, and with salts of iron and ferric oxide, derived probably from anterior decompositions. This layer of black soot increases in thickness as we proceed towards the chimney.

Lastly, the outer layer is composed of a white or pinkish substance, very soft, very adhesive, and very dry, composed of alumina, silica, and sulphate of lime, and when of great thickness its external portion sometimes melts, and forms small, greenish, vitreous grains. Ordinarily the layer is compact, but sometimes when very fat coal is used, it is flaky.

3d. Still farther towards the chimney the outer layer diminishes in thickness, and disappears after having become greyish. There is then found only the white and acid substance in contact with the iron, and the black soot which sometimes becomes from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch thick when not removed by sweeping.

With fat coal the difference is that the layer of pitch extends farther at the expense of the surface covered by the acid.

As soon as the boiler is put out of use the different products just enumerated become rapidly modified, and an examination finds them under very varied forms.

The sulphuric acid quickly attracts the surrounding humidity, becomes diluted, and penetrates by imbibition into the soot which absorbs it.

The mixture of ferrous and ferric salts acts in an analogous way, depending, however, in a very notable manner on its composition, whether ferrous or ferric. When there is only a little ferrous sulphate it attracts enough humidity to furnish its water of crystallization, and crystallizes into a very dry substance, which is only transformed slowly and has not, under ordinary circumstances, further action on the metal. The ferric salts, on the contrary, when in certain quantity, are deliquescent or not, according to the hygrometric state of the flues. I

have had specimens which in one corner of my laboratory were deliquescent and in another warmer corner were not.

The soot, when sufficiently moistened, diminishes greatly in volume. It often becomes loosened, twists like a peeling and hangs from the heating surfaces in tatters, of which a large portion falls at the first accession of heat.

The acid, once slightly diluted, attacks the iron. The ferric salts act in the same manner, and after a time, depending on the humidity of the flues, the white layer in contact with the iron grows yellowish, and then, little by little, changes into a thick layer of rust, impregnated with sulphate of iron. It is by the appearance of this layer, after the boiler has been some days out of use, that we ascertain whether the flues are humid. If it grows yellowish after two or three weeks, we can conclude that the thickness of the metal is rapidly undergoing a general diminution, and that this corrosion is due to humidity, whose cause should be discovered and removed.

As regards the preservation of boilers, all the preceding is summed up in some leading facts.

1st. Nearly all the heating surfaces of a boiler are covered with sulphuric acid, but this acid attacks them only in an insensible manner. Boilers forty years old are met with whose heating surfaces have always been covered with acid without diminishing their thickness $\frac{1}{25}$ of an inch.

2d. As soon as this acid in any way acquires humidity, it becomes very corrosive and rapidly pits the iron.

3d. An examination of the flues shows at a glance, simply by the appearance of the products, if humidity be present. If it be, the cause must at once be discovered and the effects ascertained.

The principal causes of corrosion by the acid products of the combustion of coal that I have observed are the following:

1st. *Leaks.*—Although any water that may be leaked into the strongly heated flues dries quickly, there always remains around the leak a small humid zone, where the acid in the gases of combustion preferably condenses, becomes diluted, and then acts upon the metal. In the cooler flues the effects of leaks are worse, inasmuch as the extent of surface wetted is greater.

As regards leaks, it is important to ascertain in each case whether they are due to local causes or to a general cause. If local, a repair stops them; if general, the fault may not be in the workmanship of

the boiler itself—it may be in the arrangement of the flues, in the manner of feeding, or in the forced combustion, in which cases the leaks will continue to break out as often as they are stopped. Adding another boiler often stops the leaks of the others.

2d. The humidity present at the front of boilers, and which is carried into their flues by the draught when the boilers are out of use.

I have witnessed cases where a gutter passing in front of boilers received their water when run out. This gutter also received the discharge from several gauge-cocks, so that aqueous vapor was always rising from it. After some time all the boiler plates were notably rusted.

In other cases the boiler water was run out into the ashpit, during which operation the aqueous vapor entered the flues, diluted the acid products, and, at each time the boiler was allowed to cool, pitted its plates a little. A cause of humidity that only operates occasionally suffices to destroy a boiler at the end of several years.

3d. The natural or artificial humidity of the flues.

Above all, it is necessary that water should not enter the flues when the boiler is ran out or emptied, because they would then continue humid all the time the boiler remained out of use, and the corrosion would rapidly go on. It is also necessary to prevent any water that may fall on the masonry or setting of the boiler from entering the flues.

4th. The too low temperature of some of the flues.

If the hygrometric state of the gases of combustion be such that the aqueous vapor they contain can condense on the heating surfaces of the boiler or of its feed-water heater, these surfaces will remain constantly humid and rust very rapidly.

5th. When the flues of a boiler out of use are in communication with the flues of another boiler in use, the acid vapors in the gases of combustion from the latter will condense on the heating surfaces of the former.

Heating Boilers by Electricity.—Charles Davis, of Paris, proposes to fasten a number of spirally wound platinum wires in an ordinary steam boiler, and to send through them an electrical current of sufficient strength to boil the water. He does not say how he will produce the requisite amount of electricity, nor at what cost per horse power he expects to furnish the steam.—*Dingler's Jour.* C.

MICA.

By Theo. D. Rand.

Of commonly occurring minerals, few are more remarkable than those of the mica family. Originally, the word mica was applied to a variety of minerals closely resembling each other, then supposed to be identical, but which the advance of science has shown to be distinct species, so that now the term is applied to a large class of minerals, the distinguishing characteristic of which is their readily splitting into thin laminæ.

Common mica, or Muscovite, is very abundant in most of the older rocks, it being a constituent of gneiss, granite and micaschist.

It splits into thin laminæ, or leaves, very readily. This is due to cleavage, or the property, possessed by most crystalline substances, of breaking most readily in certain planes, which bear a relation to the axes of the crystals. For instance, take a crystal, or fragment of a crystal, of galena, or of rock salt; break it into small pieces, and these, if you will, again and again, even until a microscope is needed to see the form of the grains; nearly all the fragments, large and small, will be found to be rectangular in shape, or with sides parallel to the faces of a cube, the crystals dividing readily into that form, and into no other. If fluor spar be treated in like manner, the surfaces of its fragments will be found to be parallel to the faces of an octahedron. A crystal of common feldspar, or orthoclase, similarly treated, will give rectangular cleavages on four sides, but the remaining sides will, in almost all specimens, be found to be wholly destitute of cleavage, and to break with difficulty, and irregularly. The readiness with which the specimens will cleave will be found to differ. The galena breaks with great ease into perfectly rectangular blocks, with smooth and shining surfaces, the salt likewise, but less easily; the fluor spar breaks still less readily, and more care is required to obtain a smooth surface; the feldspar breaks with great ease in one direction, and with much less ease in the other at right angles. These examples will help us to understand the cleavage of mica. It (generally) cleaves in one direction only, but in that direction its cleavage is almost perfect, and very easy indeed. To this property, and to the fact that it is unaltered

by a moderate heat, is due its large use for doors for stoves, etc., for closing the eye holes of blast furnaces, and other similar purposes. Occasionally a second cleavage exists, and when this is the case the result is long fibres almost hair-like in appearance.

Chemically, mica is a silicate of alumina and potash with a small amount of iron, magnesia and soda, and usually from one to five per cent. of water.

Another remarkable property of mica is its great elasticity and toughness. It is equaled in these respects by very few materials, and in the combination of the two it is probably excelled by nothing natural or artificial.

Granite is composed of crystals, or crystalline masses, of mica, quartz and feldspar; sometimes the crystals or masses are very small, as in common granite; sometimes very large, and when so, the mica becomes valuable; the granite is a "mica mine."

Formerly, nearly all the mica used in the United States came from Russia, whence crystals over a yard in diameter are said to have been procured; but now several mines are, and have been wrought in the United States, especially at Grafton, N. H., and in Western North Carolina.

A large amount of mica was obtained from an opening in the southern part of Chester county, Pa., not far from the celebrated Dixon's quarry. It occurred in a granite vein, in which, as is very commonly the case, the feldspar had become wholly decomposed into clay, leaving the quartz and mica unaltered. The vein was followed nearly vertically some forty or fifty feet. Crystals of mica over two feet across and weighing over a hundred pounds were obtained, much of it of excellent quality, but some of it rendered nearly opaque by dendrites of magnetic iron between the films of the mica, rendering it useless for stove purposes, but forming cabinet specimens of great beauty. The quarry, which gave promise of considerable yield (properly wrought), was neglected, until the sides of the excavation caving in, it was abandoned.

As we have stated, the varieties of mica, now distinguished by mineralogists, are numerous—the most common after muscovite are:

Biotite, generally of a dark color—the black mica so abundant in many granitic and gneissic rocks.

Lepidomelane; black, and not distinctly separated from biotite.

Phlogophite; generally brown or red—the mica occurring in limestones.

Lepidolite; a red or pink mica containing the rare earth lithia.

Mica, like most other minerals, is found to change by long exposure to atmospheric influences, but the muscovite seems least susceptible to such decomposition, and to be more stable than the feldspar which usually accompanies it,—there results a micaceous soil, so common in some parts of our country, as in Philadelphia. Often such mica becomes red and yellow in color, probably from oxide of iron, and the instances are numerous in which it has been mistaken for gold. It is believed that the class of minerals known as the vermiculites have resulted from an alteration of mica, chiefly by the absorption of water. These are characterized by a very great and powerful expansion when heated. This expansion increases the bulk enormously, and the force is sufficient to break a test tube if the mineral be heated in it.

Mica ground in a mill increases vastly in bulk and forms a loose light mass of scales not unlike bran. It is largely used in this form in the so-called mica powder as an absorbent of nitroglycerine, its peculiar elasticity rendering accidental explosion by percussion almost impossible, while it does not interfere with the energy of the nitroglycerine when exploded by a fulminate or other similar device.

To the microscopist a world of interest may be found in the micas. They frequently contain, between the layers, microscopic crystals of minerals, some of them, especially with polarized light, forming specimens of wonderful beauty. Of most minerals, sections for microscopic examination must be made by the laborious process of grinding and polishing, but in mica we may almost say the sections are made by nature, and the time required to make one section of most minerals will make at least a hundred of mica, and the thickness or thinness is a matter of perfect control.

Perhaps the richest mica in these crystals, at least in variety, is that from the locality mentioned in Chester county, Pa. Most abundant is magnetite, or magnetic iron, usually in beautiful arborescent forms, black in color, but sometimes, probably owing to a change into limonite or gothite, various shades of yellow. Quartz crystals, generally flattened, sometimes perfect, are not uncommon, and form, with polarized light, specimens more brilliant than any other mineral. Besides these, various other forms occur, the identification of which with known species has not yet been accomplished.—*Science Advocate.*

A NEW LECTURE EXPERIMENT—THE CUPELLING OF GOLD AND SILVER.

Mr. Holman, the Actuary of the Institute, has constructed a lantern for the oxyhydrogen light which combines a great many advantageous qualities. It may, at a moment's notice, be changed into a vertical lantern for showing precipitations, the action of a magnet on iron filings, etc., on the screen. It may be converted into a projecting microscope in a twinkling, and with equal facility it becomes a megascope for projecting the image of solid objects. A course of lectures by Mr. A. E. Outerbridge, Jr., of the U. S. Mint, was recently delivered before the members of the Institute on "Coins and Coinage." By the aid of Mr. Holman's apparatus the enlarged images of rare and valuable ancient and modern coins were projected upon the screen with great sharpness and brilliancy, having the lustre and effect of relief of the coins themselves, and the lecturer was enabled to show the cupellation of gold and silver, as performed in the assaying of the precious metals at the Mint, in a very beautiful manner to the entire audience, thus opening up a new field of usefulness for the projecting lantern in illustrating lectures on metallurgy.

A little "cupel" or crucible, made of calcined bone ash, was held in the focus of the light from the condensing lenses of the lantern, by means of a ring of thick copper wire. The image of the cupel appeared upon the screen greatly enlarged. The cupel was then heated to a white incandescence by means of an oxyhydrogen blowpipe. A weighed sample of gold alloy containing base metal was enclosed in an envelope of sheet lead pressed into the form of a bullet; this was dropped into the cupel and was immediately melted. As the lead became oxidized it was gradually absorbed in the cupel, forming a dark ring in the bottom. A little sheet of light was noticed moving over the surface of the molten metal as the non-oxidizable precious metal became exposed to view; then, at the moment that the lead became completely absorbed, carrying with it all the base metal originally contained in the alloy, the purified precious metal became visible as a brilliant globule, reflecting the light falling upon its surface like a mirror.

ON THE HEATING POWER OF COAL GAS OF DIFFERENT QUALITIES.

By DR. W. WALLACE.

Read at the Meeting of the Philosophical Society of Glasgow, December 3, 1879.

The extensive employment of coal gas for heating purposes, and especially for cooking, gives an interest to the question whether the heating power varies like the illuminating power, and if so, to what extent in the gas used in different towns? As regards illuminating power, we know that it varies exceedingly. In Aberdeen and Edinburgh it is 30 candles for 5 cubic feet per hour; in Glasgow, Paisley and Greenock, about 26 or 27 candles; in Liverpool, Manchester and Carlisle, about 20; in London and Dublin, 16; in Birmingham and many other English towns, 14; and in some as low as 12 candles. But as regards heating power we have no definite information, although there is a general belief that a rich gas has a greater calorific effect than one of poorer photogenic quality.

My attention having been directed to the subject by a correspondent, I caused a small apparatus to be made, in order, when opportunity offered, to test the matter practically. It is of very simple construction, consisting of a cylindrical tin-plate vessel, 8 inches in diameter and 6 inches high, with a cylindrical opening in the centre, 1½ inches in diameter, through which the whole of the products of combustion pass. It contains exactly one gallon of water. Below is a brass tube bent into a circle 5 inches in diameter, and pierced with 34 small holes, from which the gas burns with flames about ¾ of an inch high. This tube is placed 1 inch from the bottom of the vessel, and is surrounded by an outer case having a sufficient number of small holes for the admission of air. On the top of the vessel there are two openings, in one of which a delicate thermometer is placed, while the other is provided with an open glass tube.

The opportunity of using the apparatus occurred recently, when I had occasion to test, on the same day, three samples of coal, which gave gas of 33, 26 and 15 candle-power respectively. Each experiment occupied, as nearly as possible, thirty minutes, and consisted in raising one gallon of water from 60° to 160°F., and measuring the quantity

of gas consumed in the operation. The system is by no means a perfect one, but the results are strictly comparative. These are arranged in the following table:

Illuminating Power of Gas in Standard Candles.	Durability of 1 C. Foot by flame 5 inches high.		Specific Gravity Air=1000.	Comparative Value for Lighting.	Gas consumed in Heating Experiment.	Heat Units Fahr. for 1 C. Foot.	Comparative Value for Heating.
	Mins.	Secs.			Cub. Ft.		
33·07	64	45	574	4s 10d	1·916	522	4s 5d
26·24	54	40	525	3s 10d	2·200	455	3s 10d
14·75	39	35	442	2s 2d	2·888	347	2s 11½d

The heat units represent the number of pounds of water heated 1°F. by the combustion of one cubic foot of gas. I have taken Glasgow gas of 26 candles at 3s. 10d. per 1000 cubic feet as the standard of value, and it will be seen at a glance that, while the heating value rises and falls with the lighting value, the amount of difference is by no means so great in the former as in the latter.

Having made these simple but instructive experiments, I naturally wished to compare the results with the theoretical heating values obtained by calculation from the composition of the gases. Unfortunately, I had no apparatus at the gas-works where the experiments were made for analyzing the gases, and the best I have been able to do is to make the calculations from two analyses by the late Dr. Letheby, one of 12 candle gas, and the other of London Cannel gas, the illuminating power of which is not stated, but which may be assumed to be somewhere between 22 and 23 candles. The analyses are given only, as is usual with gaseous mixtures, by volume, but I have, for convenience, calculated the composition by weight.

	Common Gas. 12 Candles.		Cannel Gas. 22 Candles.	
	Vol.	Wt.	Vol.	Wt.
Olefiant gas, etc., C_2H_4,	3·8	9·5	13·0	24·9
Marsh gas, CH_4,	39·5	56·5	50·0	54·8
Hydrogen,	46·0	8·2	27·7	3·8
Carbonic oxide,	7·5	18·7	6·8	13·0
Carbonic anhydride,	0·6	2·4	0·1	0·3
Nitrogen,	0·6	1·5	0·4	0·8
Aqueous vapor,	2·0	3·2	2·0	2·4
	100·0	100·0	100·0	100·0

Specific gravity (calculated),	387	506
Weight of a cubic foot in pounds,	0·0296	0·0387
Calorific power, C.,	11,790	11,754
" " F., pounds of water heated 1° by the combustion of 1 pound of gas,	21,222	21,157
Heat units for 1 cubic foot, C.,	345	455
" " " " " F.,	621	819
Pounds of boiling water evaporated by 1000 cubic feet of gas,	639	842

We see from this tabular statement that, while the heating power of the two gases is almost identical, weight for weight, the practical result when we take the same measure of gas is very different, the Cannel being much heavier than the common gas. I calculate that in my practical comparative test I have realised about 55 per cent. of the theoretical heating power, which is pretty nearly the proportion of effective heat obtained by the combustion of coal in a fairly well-constructed steam boiler.

The question naturally suggests itself, What is the comparative cost of heating by gas and coal? The calculation is a simple one. The theoretical heating power of ordinary soft coal may be taken at 13, that is, the number of pounds of boiling water evaporated by 1 lb., equal to 29,120 lbs. for a ton of coal, value, say, 11s. 6d., being the price of 3000 cubic feet of Cannel gas, the heating power of which is, say 2500. The gas, therefore, costs 11½ times as much as the equivalent quantity of coal, or, in round numbers, a penny-worth of coal gives as much heat as a shilling's-worth of gas. When, however, we consider the handiness, the cleanliness and the convenience of gas, it is not surprising that it is extensively employed as a source of heat, as an illustration of which I may state that in my own laboratory from 250,000 to 300,000 cubic feet are consumed annually, almost the whole of which is burned for the production of heat.

English Industrial Laborers.—The iron workers of England include 140,000 laborers in furnaces and forges, 169,000 in the manufacture of machinery, 5500 in steel works, 48,000 in shipbuilding, and about 200,000 in various branches of iron and steel manufacture, making about 570,000 in all. The mining population is about 530,000 and the laborers in cotton mills about 600,000.—*Chron. Indust.*

ARE THE CHEMICAL ELEMENTS SIMPLE BODIES?

The researches which have been made in the various branches of physical science during the last few years have many of them been of unusual importance. Some—the telephone and microphone, for instance—have already resulted in the invention of instruments of great practical utility, while others have opened up new fields for research, and bid fair to effect a complete reversal of the generally-accepted notions concerning Matter. As Prof. W. B. Rogers remarked, in his Presidential Address at the 1879 meeting of the New York Academy of Sciences, "In all branches of discovery we seem to be catching the clews of far-reaching thought that stretch out where as yet no man's foot has trodden. The recent developments in chemistry, through the agency of the spectroscope, and the effects of heat in dissociation, have suggested, if they have not proved, that a number of the substances hitherto regarded as elements are hereafter to be regarded as compound. The investigation of the laws of chemical action following out the suggestions made at the beginning of the century by the great chemist Berthollet, in regard to the influence of man on chemical reaction, seems to promise most important discoveries in chemical statics and the possibility of applying mathematical reasoning and formulæ to chemical activities. The marvelous series of experiments presented recently by Crookes, in which have been exhibited the wholly unexpected phenomena which he has described under the designation of what was first referred to by Faraday as a fourth form of matter, which this illustrious experimentalist called radiant matter, seemed to open up a field of research and speculation until now wholly undreamed of. In truth, the active scientific workers have now been brought by their refined and novel researches to touch the near extremities of innumerable lines of thought and investigation, stretching out into unknown regions, whose exploration is to occupy the activity and reward the labors of a coming generation."

In discussing the question whether or not the study of the spectrum has thrown, or is likely to throw, any light on the ultimate constitution of matter, Dr. Balfour Stewart* recently referred to the fact that

* Nature. "On some Points in the History of Spectrum Analysis: an Address to the Natural Philosophy Classes at Owens College, Manchester, November, 1879."

Prout first pointed out that the atomic weights of the so-called elements are very nearly all multiples of the half of that of hydrogen, so that the various elements may possibly be looked upon as formed by a grouping together of certain atoms of half the mass of the hydrogen atom. A most remarkable series of experiments was conducted by M. Stas to test this doctrine. He came to the conclusion that the atomic weights of the various elements were not precisely multiples of the half of that of hydrogen, there being greater differences than could possibly be accounted for by errors of experiment. But Dr. Stewart, calling attention to the great difficulty of obtaining substances absolutely free from all impurity, does not admit that Stas' researches settled the point in the negative, and points to the spectrum as a likely means of throwing some light on the question. Now Mr. Lockyer's researches tend to show that at sufficiently high temperatures the so-called chemical elements, or at all events some of them, are compound bodies. These researches were not undertaken with a view sf decomposing the elements. Mr. Lockyer was preparing a map of the solar spectrum on a large scale, and the work included a comparison of the Fraünhofer lines with those visible in the spectrum of the vapor of each of the metallic elements in the electric arc. (The complete spectrum of the sun, on the scale of the working map, will be half a furlong long; in mapping the metallic lines and purifying the spectra more than 100,000 observations were made, and about 2000 photographs taken.) The final discussion of the complete photographs of the spectra of the metallic elements compared with the spectrum of the sun led to the results which are exciting so much interest at the present time.

There are certain lines in the spectra of each element which appear long and thick; and it has been found that while such a line, for instance, is exceedingly prominent in some one element, other elements appear to possess it, only not nearly so prominently. Mr. Lockyer argued from this, that on the assumption that the elements are truly elementary, the line in the other elements was caused by traces of impurity. He has, however, found that there are coincidences in the lines of metallic spectra of two perfectly distinct kinds. There are coincidences of lines which are not the prominent lines of any one spectrum, and they give no signs of that variability of brightness that might be expected to characterize lines due to impurities; these lines he has called basic lines. In Mr. Lockyer's own words, "The temperature of the sun and the electric arc is high enough to dissociate some of the

so-called chemical elements, and give us a glimpse of the spectra of their bases, just as in the case of the various salts of calcium there is a temperature which just allows us to get a glimpse of a line indicating the metal calcium common to them all."

To determine whether these basic lines varied in their behavior from other lines of spectra taken at random, Mr. Lockyer had recourse to the spectrum of sun-spots. The sun is surrounded by an enormous atmosphere which is supposed to contain the vapors of such metals as iron and magnesium; but whether this be so or not, Mr. Lockyer argued that the atmosphere would certainly be hotter at bottom—near the photosphere—than higher up, and that the spectrum of the atmosphere close to the photosphere would differ from that of any higher region, and therefore from the general spectrum of the sun. In observing the spectrum of a sun spot, or a prominence, the spectrum of an isolated mass of vapors in the hottest region open to inquiry can be determined, and Mr. Lockyer found that this spectrum differed greatly from the general spectrum of the sun. The whole character of the spectrum of iron, for instance, is changed when we pass from the iron lines seen among the Fraünhofer lines to those seen among the spot and storm lines. As therefore the spectra of spots and prominences are from the hottest region of the sun, Mr. Lockyer employed them for testing these basic lines. The result has led him to conclude that their appearance in two or more spectra is dependent solely upon high temperature. The basic lines are more prominent in the spectra of spots than in the spectrum of the sun; they are, moreover, more prominent at epochs of sun-spot maximum than during times of minimum. The statement, then, that the spectrum of each element consists only of lines special to that element, is found to be insufficient when the highest temperatures and the greatest dispersions are employed.

A clearer conception of what is meant by the so-called elements being split up at a very high temperature will be gathered from the following illustration, given by Dr. Balfour Stewart: "If we apply a very powerful source of electricity, we obtain certain peculiar lines from the vapor of calcium. Now if we could catch hold of and segregate—put into a box, as it were—all these minute entities that give us this suspicious line at a high temperature, and, further, if we could keep their high temperature up, I think it is probable that we might obtain something which is not calcium, or, at any rate, something simpler than the molecule of calcium as this appears at lower tempera-

tures. But we are not yet able, and perhaps we may never be able, at an ordinary temperature, to present the chemist with some other substance derived from calcium, which is not calcium."

Much, of course, remains to be done before Mr. Lockyer's views will be universally accepted. The indecomposable character of the bodies which we have hitherto considered elementary has for a long time been considered doubtful. Mr. Lockyer, however, is the first to come boldly forward with experimental proof. What the final result of the discovery will be we cannot foretell. A physical problem, as Dr. Stewart says, begins like a rivulet. At its first introduction it is small and seemingly unimportant; constantly, however, as it winds along it receives accessions from various quarters, until at length it becomes a mighty river that is finally merged in the unfathomable ocean. This course is followed by all such problems. Each begins small, grows broader, and will finally bear us on to the unknown if we trust ourselves to its guidance.—*Journal of Science.*

Carbonic Acid in its Relations to the Winds.—Marié Davy states that the quantity of carbonic acid, at Montsouris, in one hundred thousand volumes air of varies between 22 and 36. He was at first inclined to attribute these variations to the neighboring influence of Paris, which is an abundant source of carbonic acid; while the woods and cultivated fields, at least during the season of vegetation, are an equally active cause of its disappearance. But he found that the northern winds, which come from Paris, contain less carbonic acid, on the average, than the southern winds, which blow directly from the country. He therefore suggests, as an explanation of the phenomenon, that the carbonic acid is found in greater proportion below than above the clouds. The south or southwest winds plough the surface of the ground, but the north or northwest winds plunge from the upper regions of the atmosphere towards the ground. Since 1864 he has thought it important to draw a careful distinction between the equatorial current and the rotary movements which accompany it. The changes of the wind, of the barometer, of the thermometer, and of the hygrometer, are due to the latter, while the proportion of carbonic acid depends upon the former.—*Comptes Rendus.* C.

REMARKS ON THE NEW METALS FROM GADOLINITE AND SAMARSKITE.

By M. M. DELAFONTAINE.

Since M. Marignac and I published our memoirs on Terbia, in March, 1878, the real or supposed discovery of ten other rare earths has been announced by different chemists—namely, mosandria, philippia, ytterbia, decipia, scandia, holmia, thulia, samaria, and two others not yet named. As may be imagined, such a multiplication of bodies difficult to isolate and characterize has provoked skepticism, and it has been suggested that some of them may be duplicates. If the Academy will permit me, I will communicate my views on this subject, as the result of my own researches.*

In my researches on gadolinite and samarskite, I have always attached great importance to the atomic weights. When the equivalent of a base is found to be higher than that of the other members of the same group (decipia and ytterbia, for instance), I have not had the least doubt of the specific existence of this base. But, if this equivalent, on the contrary, should be intermediate between two others (philippia as compared with yttria and terbia), I naturally have multiplied experiments to make certain that I am not working with a mixture of known bodies. In this case the physical characteristics have sometimes been of great help. For these reasons, therefore, ytterbia, decipia and philippia appear to me definitely acquired for science.

Scandium is unknown to me; I can say nothing about it.

Nothing has taken place to make me change my opinion upon mosandrium since I proposed to erase it from the list of elements.

Samarium.—M. Lecoq published in February and August, 1879, two notes, one on a new earth obtained from samarskite and the other on samarium. The properties which he attributes to his unnamed earth do not appear to me to differ essentially from those of decipia, or

* Not having been for some time in a position to see the *Comptes Rendus*, I only know some of the notes on these new metals from what has appeared in the *Chemical News* of London. If, therefore, there is some misunderstanding on my part, it must be attributed to a want of sufficient information.

rather to a mixture of decipia and terbia: samarium is only characterized by absorption rays, which appear to embrace a portion of those of decipium. I do not know any facts which would lead me to imagine that decipium is not homogeneous; its absorption rays increase and diminish together in all the treatments to which I have submitted it. The discovery of samarium therefore demands verification by further experiments.

MM. Marignac and Soret have shown that Bunsen's erbia is a mixture of several bodies. With the assistance of M. Thalén, M. Clève has repeated their experiments with the same results. But the *savant* of Upsala has gone further than those of Geneva; he does not hesitate to give names to the supposed new metals which he believes to be the cause of certain spectroscopic differences. According to him, the ultra-red ray discovered by M. Soret characterizes thulium; the red and green rays ($\lambda = 640$ and 536) belong to holmium,* whose oxide is yellow and the nitrate less easily decomposed by heat than that of erbium; beyond this he has neither obtained the first nor the second in a state of even approximate purity.

Samarskite contains very little of the old erbia of Bunsen: the absorption spectrum of this latter is very feeble with the solutions obtained from it, and in particular the green and blue bands ($\lambda = 523$ and 488) of erbia (in a restricted sense) are feeble; on the contrary, the indigo band ($\lambda = 452$) shows much better. After having separated didymia, decipia, and almost all of the terbia, I submitted the formiate of the earth to fractional crystallization; the first products gave from 49 to 47 per cent. of base. They were reunited and recrystallized several times. In this way was separated a salt rich in terbia and mother liquors richer in yttria: these were rejected. The rest, calcined and combined with nitric acid, showed the indigo band very strong, and the others more feeble. This nitrate, dissolved or in crystals, was perfectly colorless; its base, of a beautiful clear yellow, had the equivalent 98 ($\gamma o = 74$, $\pi o =$ about 115). This was submitted to a series of partial decompositions by heat, which divided it into six products (A to F). The earth from the first, slightly clearer, had the equivalent 102; the crystals of its formiate were slightly rose-colored; its absorption spectrum showed the absorption rays of erbia (in a restricted sense), but deeper. The four products following (B to E)

* M. Soret likewise adds the indigo band, $\lambda = 452$.

contained a more colored base; its nitrate, which was colorless, gave a spectrum consisting only of the red (640) and the green (536) rays, narrow, but much stronger than before, and of the large indigo band (448 to 455). The green ray of true erbia was reduced to a narrow trace; the blue had disappeared. These earths, B to E, could not be split up into yttria and terbia by any known means. Finally, the product F gave a feeble spectrum; its coloration and its atomic weight were less than those of the original mixture.

I have called philippia the yellow oxide, distinct from terbia, which forms the bulk of the earths of which I have just spoken. It properties are those of the earth X of M. Soret and of M. Clève's holmia; this last-named, being a duplicate, should not be retained.

In strictness it may be supposed that philippia is a mixture of two oxides, one of which gives the indigo band (448 to 455), and the other the rays 640 and 536; but I know of no fact in favor of such a conclusion.

The so-called euxenite from North Carolina contains still less of the earths giving absorption spectra than samarskite—a trace only. Besides a notable proportion of terbia I have obtained from it a straw-yellow earth, with an equivalent ranging about 90, without absorption spectrum, and which does not appear to be a mixture of terbia and yttria. I am not yet sure whether samarskite contains it, and in particular whether my philippia may be soiled by it: this is a point which I hope to clear up very soon. I am also examining another base from samarskite which appears to have a great resemblance to ytterbia.—*Comptes Rendus.*

Magneto-mechanical Sorting Machine.—Breuer and Schumacher have invented a machine for separating the turnings and borings of brass and copper from those of iron and steel. The mixed metals fall upon a magnetized cylinder or drum, to which the iron and steel adhere while the copper and brass fall into a special reservoir below. There are two hollow cylinders, rotating in the same direction, so that the iron which escapes from the first cylinder is retained by the second. The surface of the cylinders is formed of flat bands or strips of soft iron alternating with strips of copper; each of the iron bands is in contact with a row of horse-shoe magnets. The adherent metal is removed by revolving brushes.—*L'Ing. Univ.* C.

Poisonous Toys.—The Parisian police have recently seized a number of caoutchouc toys, on account of the employment of poisonous colors in their manufacture.—*Chron. Ind.* C.

Coral Cutting.—The coral fishers of Italy reside mostly at Naples and at Torre del Greco. A school has been lately organized at the latter place, in an old monastery, for the purpose of giving special instruction in coral cutting and bringing that art to a still greater degree of perfection.—*Chron. Ind.* C.

Variations in Spectra.—Wüllner discusses the various theories of Angström, Plücker, Hittorf, Lockyer and Zöllner, in regard to the dependence of spectra upon impurities, temperature, pressure, etc. From a long series of experiments with nitrogen, he concludes that the changes from band to line spectra depend principally upon the diminishing number of the luminous molecules.—*Wied. Ann.* C.

Analogy between Fluidity and Galvanic Conductivity.—O. Grotrian finds an interesting relation between the reciprocal of the constant of friction in fluids and the galvanic conductivity of a number of salt and acid solutions. Let t designate the temperature of the fluid, f the temperature coefficient of fluidity and k the conductivity. Then the value of the coefficient $\frac{df}{dt}\frac{1}{f}$, in a change of concentration, always alters in the same direction as the corresponding coefficient of conductivity $\frac{dk}{dt}\frac{1}{k}$.—*Wied. Ann.*

New Luminous Tubes.—Trève introduces a Fizeau condenser into a great Geissler tube. The two poles of a current from a Ruhmkorff coil terminate in this condenser, by means of the ordinary electrodes, which are soldered into the glass and are attached to the 11th and 12th sheets of tinfoil. When the induced current passes into the condenser, if the tube still contains air at ordinary pressure, the usual rumbling is heard. If a vacuum is gradually made in the tube, the rumbling diminishes, and when the pressure falls to ·003 or ·004 m. (·118 to ·157 in.) no sound is heard; but a brilliant white light appears, shimmering like pearls from the leaves of the condenser, and entirely different from the phosphorescent, pale and flickering light of the Geissler tube.—*Comptes Rendus.* C.

Railway Sleepers.—The Belgian government has decided on the abandonment of wooden railway sleepers and the use of those of iron. Its example will doubtless find imitators, if indeed the example be not improved upon, and steel be used eventually instead of iron. It is not the longitudinal sleeper that has been adopted, but a German system of cross sleepers.—*L'Ingen. Universel.* C.

The Buda-Pesth Artesian Well.—The depth is 970·48 metres (3183·9 ft.); daily supply 7600 hectolitres (200,781·4 gal.); temperature 74° (165·2 F.); mean increase of earth-temperature 1° for 12·61 m. (1°F. for 22·98 ft.). The water is strongly impregnated with carbonic acid, together with some nitrogen and sulphuretted hydrogen; it contains 1·131 grs. of salts per litre (66 grains per gallon), principally sulphates and carbonates of potash, soda, lime, magnesia, with some chlorides. It resembles the Kaiserbad water, at Ofen.—*Jahresb. der K. K. geol. Reichsanst.* C.

Capillary Electrometer.—E. Debrun has presented to the French Academy a modification of Lipmann's electrometer. He avoids the use of a microscope, by observing displacements of the mercury in a cylindrical tube, with a diameter of a quarter of a millimetre (·01 inch), and fifteen centimetres (4·9 in.) long, divided into millimetres; this tube makes an angle of 10° with the horizon. The change of level is about seventy-five millimetres (2·75 in.) for a variation of a volt, which gives, with a vernier, a sensibility of $\frac{1}{750}$ of a volt. The tube is divided, experimentally, into parts of equal electro-motive force.—*Comptes Rendus.*

Deprez's Magneto-Electric Machine.—Deprez uses a horse-shoe magnet, placing between the two branches a Siemen's coil, which is revolved around an axis parallel to the branches of the magnet and provided with proper commutators. The length of the helix is nearly equal to that of the rectilinear branches of the magnet, so as to use nearly all the inductive power of the branches *. With a battery of five Bunsen elements and a magnet weighing 1·7 kilogrammes (4·54 pounds), he obtained as satisfactory results as with a Gramme machine, which had a permanent magnet weighing at least 20 kilogrammes (80·4 pounds).—*Bull. de la Soc. Franc. de Phys.* C.

*See JOURNAL OF THE FRANKLIN INSTITUTE, August, 1879.

The Pyrophone.—M. Kastner has given the name of pyrophone to an invention based upon the sounds which are produced by the hydrogen flame in tubes of glass. The instrument is played with a key-board like a piano, and the notes are remarkably sweet and sonorous.—*Badeblatt.* C.

Prof. Crookes in Paris.—On the invitation of M. Wurtz, Prof. Crookes took his apparatus to Paris and repeated his experiments upon radiant matter before the medical faculty, and also at the Paris observatory in a soirée given by Admiral Mouchez. The experiments were remarkably successful and were received with great applause.—*Les Mondes.* C.

Wide Diffusion of Copper.—Dieulafait has published a memoir upon the existence of copper, in a state of complete diffusion, in all the rocks of primordial formation and in all the sedimentary deposits which are directly derived from the primordial. As principal consequences of this fact he points out: 1. The constant existence of copper in the sea waters of ancient and modern times. 2. The origin and mode of formation of copper ores. 3. The necessary presence of copper in all the mineral waters of azoic regions.—*Ann. de Chim. et de Phys.* C.

Action of Nitrates on Nitric Acid.—Alfred Ditte finds that metallic nitrates may be divided, in regard to their action in contact with fuming nitric acid, into three well-marked classes: 1. Some dissolve in large quantities and combine with the acid so as to give rise to acid salts well defined. 2. Some, after having been deprived as much as possible of their water of crystallization, dissolve with ease; the solubility increases with the temperature, and in cooling, hydrous nitrates are deposited, but containing less water than the crystals which are formed from the liquid. In this way he has obtained several new hydrates. 3. A third class, the most numerous of all, contains salts which are insoluble, or only slightly soluble, at all temperatures. Potash and soda are placed in different groups. Lithia is ranged with soda; and rubidium, caesium, thallium and ammonium on the side of potash. All the alkaline nitrates are anhydrous except that of lithia, which crystallizes with five equivalents of water below 10°C. (50°F.), and that of soda, which forms below 0°C. (32°F.) a hydrate containing fourteen equivalents of water.—*Ann. de Chim. et de Phys.* C.

Swiss Anthracite.—Late analyses of the anthracite coal of Valois show about 90 per cent. of carbon and hydrogen and $8\frac{1}{2}$ per cent. of ashes. Experiments with American heaters show that it is capable of replacing the Pennsylvania coal, which is sometimes imported at great cost. It has also been tried successfully in locomotives.—*Les Mondes.*

C.

Modifications in the Composition of the Atmosphere.—Ph. Jolly has made numerous analyses of the air near Munich, which show a variation in the percentage of oxygen dependent upon the direction of the wind. When the wind is N. or N. W., the percentage is about 20·92; when it is S. E., S. or S. W., the percentage is only 20·56.—*Les Mondes.* C.

Gas in Metallurgy.—The report of the use of gas from natural springs, in some American puddling furnaces, is attracting the attention of European metallurgists. At the *fontaine ardente* of Saint-Barthélemy, in France, there is a natural gas-well which has been allowed to run to waste for centuries. Preparations have been lately made to make some economical use of this apparently inexhaustible supply, and some sanguine hopes have been expressed that it may convert the province of Dauphiné into a French Pennsylvania.—*Chron. Industr.* C.

Influence of Shape upon Attraction.—C. Lagrange refers to the following proposition, which he demonstrated two years ago: "When attraction varies inversely as the squares of the distance, if the distance is considerable, any mass acts with maximum, mean and minimum energies, in three rectangular directions which are respectively the axes of minimum, mean, and maximum inertia." From this proposition he deduces the following results: "1. A mass of any form, at a certain definite distance from its centre of inertia, acts with maximum, mean and minimum energies, in three rectangular directions which coincide respectively with the three axes of minimum, mean and maximum inertia. 2. The relative positions of a point and of a material system, submitted to their mutual attraction, are determined by the stable axes of equilibrium in the system; the axes of minimum, mean and maximum inertia are respectively axes of stable equilibrium, stable in one plane and unstable in a perpendicular plane, or unstable." The first of these deductions he regards as fundamental in the mechanical theory of crystallization.—*Acad. Roy. de Belg.*

Network of the Photosphere.—Lamey having asserted that he had observed the photospheric network on the solar disk with a six inch telescope, Janssen states that he must have mistaken the willow leaves or rice grains for the phenomenon in question. The photospheric network is made up of the collection of points where the solar granulation is modified, in such minute details that they can be seen only by large instruments with powerful eye-glasses. Under these circumstances the field of view is so limited that it is impossible to embrace a sufficient extent of surface to show the network. It becomes visible only upon very large instantaneous photographs.—*Comptes Rendus.*

Book Notices.

A Practical Treatise on the Combustion of Coal, including Descriptions of various Mechanical Devices for Economic Generation of Heat by the Combustion of Fuel, whether Solid, Liquid or Gaseous. By William M. Barr. Yohn Brothers, Indianapolis, Ind., Publishers. 1879.

This book seems to be intended to give, in a small space, the theory of the combustion of coal to those who cannot readily follow the various technical works on the subject. It treats on the physical properties of coal, the atmosphere, various fuels, analyses of coal, combustion and the products of combustion, heat, etc.; construction of furnaces, methods of firing, spontaneous combustion of coal, coal dust as a fuel, petroleum as a fuel, ordinary gas, etc. It presents a compilation of existing knowledge on its various subjects, including nearly all that any one but the technical student will desire to read, and in such shape as to be easily understood. Where it touches on theoretical chemistry it is not so complete as to enable one to thoroughly understand the "why" of the several phenomena talked of or steps described, as in the analysis of coal for example. Again, on the subject of liquid fuel and gaseous fuel there is very little comparison of opinion or discussion. A valuable essay of Rankine, published in the United Service Institution Transactions, being lacking on liquid fuel for example. Something, however, will be found on every point that will probably arise in every-day practice, and what there is is in an excellent form for ready reference.

In addition to this, it may be generally stated that there is no *single book* in English which gives so much in regard to the combustion of coal. Everything in the book is useful, and is written in a form which cannot be complained of as regards simplicity of presentation.

D.

LABORATORY TEACHING: OR PROGRESSIVE EXERCISES IN PRACTICAL CHEMISTRY. By Charles Loudon Bloxam. 4th edition, with 89 illustrations. 12mo. Philadelphia: Lindsay & Blakiston. 1879.

This work, which is well known to teachers of chemistry, first made its appearance in 1869. It is a departure from the old method of teaching analytical chemistry, very commonly followed yet, in that, instead of requiring the student to study and memorize the several reactions of the metallic and non-metallic bodies before proceeding to examine an unknown substance, the author seeks to familiarize the learner with the subject by a series of progressive exercises or lessons, accompanied by examples for practice. The author does not pre-suppose any chemical knowledge on the part of the pupil, and directions for the use of the tables, for performing the various chemical manipulations, are found given where the pupil requires to know them. The book is highly practical throughout, and its scope is well indicated by its title.

W.

LECTURES ON POPULAR AND SCIENTIFIC SUBJECTS. By the Earl of Caithness, F.R.S. 12mo. London: Trübner & Co. 1879.

These lectures, delivered by their author at various times and places, are eight in number, and comprise in this second enlarged edition quite a variety of subjects, those on coal and the steam engines being the most interesting. In the former it is stated that the total available deposits in the British coal fields, at depths not exceeding 4000 feet, and in seams not less than one foot thick, is 90,207,285,398 tons, and taking into account seams which may yet become available, lying under the Permian, New Red Sandstone, and other superincumbent strata, this estimate is increased to 146,480,000,000 tons, which, at the present annual rate of production throughout Great Britain—namely, 123,500,000 tons—would last 1186 years. The United States is credited with having 120,000 square miles of workable coal beds,

and peat bogs of considerable extent, in which a substance exactly resembling cannel coal has been found.

The lecture on the steam engine is a brief history of some of the important steps which led to this wonderful invention, and, although it does not contain anything which has not been said often before, yet will be found, like all of the lectures, to be presented in a popular and pleasing style. In conclusion, we desire to call attention to the beautiful printing of this book from the "Ballantyne press." J. B. Lippincott & Co. have also their name on the title page. N.

BRAIN WORK AND OVER WORK. By Dr. H. C. Wood. 16mo. Philadelphia; Presley Blakiston. 1880.

We welcome heartily each addition to the series of American Health Primers, so ably edited by Dr. W. W. Keen, and this latest one is of the utmost importance, for nothing can be more sad than to see a man of fine intellectual endowments breaking down from the vain attempt to do two days' work in one, as so many Americans are trying at the present time.

The author has divided his little book into seven chapters, and after showing in his introductory one the alarming increase of nervous disorders, he gives the general causes of them in another, while the remainder of the treatise is taken up with a discussion of the effects of emotional and intellectual work—the proper age for labor, woman's work, rest in labor and in sleep, necessary recreation, in which the vexed Sabbath question enters, and the plan so strongly advocated by Dr. Mitchell of "camping out." We trust, in conclusion, that this little book will find many readers, and they will profit by the excellent advice Prof. Wood gives. N.

THE WORKSHOP COMPANION; a Collection of Useful and Reliable Recipes, etc., for the Household and Shop. 16mo. New York: Industrial Publication Co. 1879.

This is an enlarged edition of a little Pocket Manual, known as the Amateur's Handbook, and contains quite a variety of recipes, many of which have been long known and found to be of decided value. The practical hints are in many cases excellent, and in addition to the matter contained in the book being arranged alphabetically, we have also what no volume should be without, a very full index.

N.

ELECTRIC TRANSMISSION OF POWER: ITS PRESENT POSITION AND ADVANTAGES. By Paget Higgs, LL.D. 12mo. London: E. & F. N. Spon. 1879.

In this little work on a subject which is attracting at the present time a great deal of attention from scientific men, the author has collected the best data that he could find to prove that it has a wide field of usefulness before it, and after describing briefly the Gramme, Brush, Wallace-Farmer and Siemens machines, a chapter is given on their efficiency, and its applicability to long and short circuits. Use is made largely of the very valuable report of Profs. Houston and Thomson on Dynamo-electric Measurements, published by the Institute, and which has become such an authority, and the investigations of Siemens, Mascart and Hopkinson are referred to. Despite many faults, that would have been perhaps avoided by Dr. Higgs if the Horatian rule of waiting ten years had been observed, the work can be read with profit by almost every one. N.

THE MICROSCOPE IN MEDICINE. By Lionel S. Beale, M.B., F.R.S. Fourth edition, much enlarged. 8vo. London, 1878, also Philadelphia: Presley Blakiston. 1878.

We have before us the fourth edition of Prof. Beale's work, "The Microscope in Medicine," a book which it gives us pleasure to recommend for careful study to every student of microscopy, whether he be a physician or naturalist. He will find in it not only a clear exposition of the methods employed in order to obtain the best results in microscopical examination of tissues, but also a description, profusely illustrated with drawings by the author's own hand, of the histological details of tissues as seen under the microscope.

In the first chapter we find full directions given of how to employ the different necessary accessory instruments; how to use reagents in order to develop certain details; how to examine objects; how to measure them, and to make records by means of drawings upon paper, wood and other materials.

The second chapter is devoted to the consideration of hardening soft tissues, and methods are given for removing the earthy salts from bone, so that sections may be cut.

The third, fourth and fifth chapters contain directions for cutting sections of hardened tissues, and for staining them so as to differentiate the histological details as well as for permanently mounting preparations.

The sixth chapter treats of the different methods employed to reveal the vascular system in healthy as well as morbid tissues by means of injecting, and will prove to the readers one of the most interesting parts of the book.

In the seventh chapter the author gives a concise description of his method of preparing tissues for microscopical examination, which is an excellent one if a certain class of work is desired by the student, but which does not give equally good results in all cases.

The second part of the book is devoted to the description of tissues when prepared and viewed under the microscope, and thus forms a source of information to every one interested in the minute anatomy of animal organisms.

The last two chapters give full directions of how to obtain crystals from animal fluids, and of how to conduct spectrum analysis by means of the spectrum microscope.

The book is profusely illustrated, containing over 500 engravings, most of which are drawn to a scale so that forms seen in the microscope may be compared with them, not only in regard to shape, but also in regard to size.

The great value of the work consists in the fact that the author has worked the different processes and given them a fair trial, and recommends only those which by personal experience he has found to be reliable, so that the student, if he closely adheres to the directions given, will be sure to succeed. S.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 18th, 1880.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 148 members and 81 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that eight persons were elected members of the Institute at their last meeting. Also that two vacancies existed in the Board, caused by the election of Mr. Henry Cartwright as Vice-President, and Dr. Norris as Secretary.

The following donations to the Library are reported by the Secretary:

Specifications and Drawings of Patents from Sept. 26th to Dec. 31st, 1878, and Jan. 1st to 9th, 1879.
From the Commissioners of Patents. London.

Holtzapffel's Turning and Mechanical Manipulation. Vol. 4.
From the Author.

On the Fixed Signals of Railways, by R. C. Rapier.
Railway Materials. Catalogue, by Ransome & Rapier.
From Fred'k Ransome.

Specifications and Drawings of American Patents for August and September, 1879. From the Patent Office. Washington.

Reports on Experiments in Boiler Bracing.
From the Bureau of Steam Engineering, Navy Dep't, Washington.

Biographical Sketch of William Penn.
From the Historical Society of Penna.

Annual Report of the Chief of Ordnance to the Secretary of War for 1879.
Ordnance Memorandas Nos. 1, 2, 4 to 10, 12 and 13.
From the Chief of Ordnance. Washington.

Annual Report of the Secretary of the Treasury on the state of the Finances for the year 1879.
Annual Reports of the Director of the Mint to the Secretary of the Treasury for 1873, 1875 to 1879.
From the Secretary of the Treasury.

Ninth Annual Report of the Trustees of the State Industrial School for Girls, of State of New Jersey, for 1879. From R. Bingham.

Thirty-fourth Annual Report of the Director of the Astronomical Observatory of Harvard College. By E. C. Pickering. Cambridge, 1880.
Annual Report of the Supervising Inspector-General of Steam Vessels to the Secretary of the Treasury for 1879.
From the Supervising Inspector.

Documents relative to the Colonial History of the State of New York, by E. B. O'Callaghan. Vol. 9.
From the State Library, Albany.

Centenary of the Birmingham Library, 1779.
From I. Norris, M. D.

Mr. George S. Strong read the paper announced for the evening, on "Incrustations and Scale in Boilers."

In introducing his subject, he said that while a great deal of attention had been given to perfecting the engine, too little attention had been paid to the evaporative power of boilers. It is a fact recognized by the best engineers that a scale of one-sixteenth of an inch causes a loss of twenty per cent. in the evaporative power of a boiler, and the increase in loss is very rapid as the thickness of scale increases.

He ventured the opinion that eighty per cent. of the boilers in the country have a scale of from one-sixteenth to half an inch, and even more. The difficulty arises from vegetable and earthy matter held in suspension, and solid matter held in solution. These, becoming heated, are precipitated and settle to the bottom and sides of the boiler or in flues and tubes where these are used. When there is only mud and vegetable matter in the water, the deposits can be blown out and the boiler thus kept clean. But where there is mineral matter in the water, which is generally the case, it becomes a most difficult matter to keep the boiler clean.

Mr. Strong described the mineral deposits made on boilers. The most common and dangerous of these is sulphate of lime. It is precipitated by heat in small crystals or flakes, which, after forming a thin, hard scale, breaks off and forms again in bunches, making the boiler liable to be burned, especially if fired with soft coal. A high degree of temperature, 290 degrees Fahr., is required to precipitate the sulphate of lime. Carbonate of lime, magnesian lime, oxide of iron, alumnia and sulphuric acid are also sometimes found in water and form scales, giving great trouble. They are all precipitated by heat generally of 212 degrees Fahr.

A number of photographs were exhibited by the lantern in connection with this subject, and the paper was discussed by Messrs. Cooper, Cartwright and Orr.

The Secretary read a short paper describing the "Burgess Portable Mechanical Blowpipe," and the various attachments for different purposes.

This is a simple and efficient device for maintaining a continuous supply of air for blowpipe use. The general appearance of the blowpipe was shown by engravings. The pump cylinder is mounted on an arched stand, and contains a piston having a valve opening upward. The piston is connected with the foot pedal by a forked connecting rod, and is moved by a slight and easy motion of the foot.

The upper end of the pump cylinder is closed, with the exception of a valve aperture, which is covered by a valve opening upwards into a cylindrical air reservoir secured to the upper end of the pump.

Near the top of the air reservoir there is a nipple to which is attached a flexible tube communicating with the blowpipe. The pipe outlet is much smaller than in the mouth blowpipe, to permit of maintaining a pressure, which may be increased or diminished by a quick or slow motion of the treadle. The air chamber is easily filled, and when charged affords a *constant* supply of pure air. The machine is light and portable, weighing but twelve pounds, and measuring 24 inches in height. The pump cylinder is 2½ inches in diameter, with 3 inch stroke. For light and delicate work, when a gentle flame is required, a pressure of one or two pounds is given, but for brazing, annealing, fusing, etc., when a large flame is necessary, a few rapid strokes of the plunger will raise the pressure in the receiver to from 10 to 12 pounds, which can be sustained with but little exertion.

Mr. J. Elliott Shaw gave an exhibition of its power in the melting of hard spring brass and other refractory metals.

One of Edison's electric lights was then shown, for the first time in this country outside of Menlo Park, and it was kindly obtained for the Institute by Mr. Addison B. Burk. It was mounted on a statuette representing Mercury, and an attempt was made to light it by means of the Brush dynamo-electric machine belonging to the Institute. The carbon was raised to a white heat until the lamp gave forth a light greater than the average one furnished by the lamps at Menlo Park.

Mr. Burk, to whom the lamp had been given by Mr. Edison, said that the machine in use was not suited to the lamp, and that Mr. Edison had warned him that this was the case, but as there was great curiosity to see the lamp, he had determined to attempt to show it. The light was maintained for five or ten minutes, and then the current increasing rapidly, apparently burnt out the connections, and in a moment the lamp was broken.

Mr. Burk reported that at his last visit to Menlo Park he had found workmen engaged in putting up a building to be used as a model of a central office, in which are to be placed twenty generators. Mr. Edison expects, when the building is completed, to be able to demonstrate the cheapness of the light. He is at present engaged in experimenting with various natural fibres in place of paper, but considers the carbon from paper entirely satisfactory. The horse-shoes are not now made

from cardboard, but from pure paper made for the purpose without admixture of kaolin with the cellulose. One of the lamps at Menlo Park had been burning 804 hours on Saturday, and seven 720 hours, while the others were of varying age, from several hundred to a few hours.

Inquiries were made as to the horse-power employed in running the dynamo-machine which furnished the light, apparently with the view of ascertaining its cost, but Prof. Houston explained that the engine and machine would undoubtedly maintain several such lights.

Two Brush electric lights were then exhibited. The lamps are made on a new principle, and maintained a very steady light. Prof. Houston explained the difference between the light from incandescence, as shown in the Edison lamp, and the light from the volatilization of carbon in the voltaic arc, as in the Brush lamps.

The Secretary's report included an account of the Tapley Letter File, Burns' Security Sash Locks, Longaker's Liquid Measuring Can, for coal oil, etc., Eldridge's "Sautophone," an instrument to assist the hearing of persons, and the "Waterbury Watch." By the aid of the megascope, the latter was shown on a large scale upon the screen, the movement being distinctly seen. Papers were read, on Steel Vessels; the Microscopic Detection of Arsenic; the Machinery for the Removal of the Cleopatra Needle; on the Use of the Telephone in Europe; Electric Lights at Sea; the Bursting of the English 100-ton Gun; the Tay Bridge Disaster; the Cental System; the "Topophone;" and Modifications of the Audiphone.

The invitation of the Board of Managers to Mr. A. E. Outerbridge, Jr., of the United States Mint, requesting him to repeat his two lectures on the "Art of Coining," etc., in a larger hall than that of the Institute, was read by the Secretary, and Mr. Outerbridge's acceptance of the same, with his suggestion that the proceeds be devoted to the Library Fund.

Nominations for Managers being announced as in order, Mr. Henry Cartwright proposed Mr. Frederick Graff and Mr. W. L. Dubois. No others being offered, Mr. Weaver moved that the nominations be closed, which was carried, and tellers being appointed, the Secretary was directed to cast the vote of the Institute for the gentlemen named, and they were declared by the President duly elected.

On motion, the meeting adjourned.

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4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with same motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

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